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MINIMUM INDUCED DRAG CONFIGURATIONS WITH JET INTERACTION

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Summary

A theoretical method is presented here for determining the optimum camber shape and twist distribution for the minimum induced drag in the wing-alone case without prescribing the span loading shape. The same method was applied to find the corresponding minimum induced drag configuration with the upper-surface-blowing jet. Lan's Quasi-Vortex-Lattice Method and his wing-jet interaction theory has been used. Comparison of the predicted results with another theoretical method shows good agreement for configurations without the blowing jet. More applicable experimental data with blowing jets are needed to establish the accuracy of the theory.

1. LIST OF SYMBOLS

$[A]$	matrix $[N_{WW}]$ after transformation
a_j	Fourier series coefficient
a_{kj}	the element of the transformation matrix $[A]$
AR	aspect ratio
$[B]$	matrix $[N_{WJ}]$ after transformation
b	span
b_{kn}	the element of the transformation matrix $[B]$
c	chord length
\bar{c}	reference chord length
c_a	average chord length
$c_{d,i}$	sectional induced drag coefficient
c_l	sectional lift coefficient
c_m	sectional pitching moment coefficient
C_L	total lift coefficient
\bar{C}_L	lift constraint
C_m	total pitching moment coefficient
\bar{C}_m	pitching moment constraint
ΔC_p	pressure coefficient
C_μ	jet-momentum coefficient
d_i	local induced drag
\vec{e}	unit vector tangent to jet path
E_k	step direction vector defined by Eq. (42)
f_1, f_2, f_3	the length of each section in the spanwise direction
g_n	a scalar defined by Eq. (26.a)
h_1, h_2	the length of each section in the chordwise direction
$[I]$	interpolation matrix

l	local lift
M	Mach number
M_1, M_2, M_3	the numbers of spanwise strips plus one in each section
\vec{n}	unit vector normal to jet surface
n, s	jet axis system
$[N]$	normal velocity influence-coefficient matrix
N_1, N_2	numbers of vortices in each section along the chordwise direction
N_c	$= N_1 + N_2$
N_j	total number of jet vortices in the outer flow
N_t	total number of wing vortices over the semi-span
q	dynamic pressure
$[S]$	tangential velocity influence-coefficient matrix
S_w	wing area
T	$= \rho_o / \rho_j$
t_j	jet thickness
V	velocity
\vec{V}	unperturbed velocity vector
\vec{v}	perturbed velocity vector
\vec{v}_{je}	jet-entrained-flow velocity vector
x, y, z	wing-fixed rectangular coordinates with positive X-axis along axis of symmetry pointing downstream, positive Y-axis pointing to right, and positive Z-axis pointing upward
z_c	coordinate of camber surface
α	angle of attack
α_t	local angle of attack
γ	nondimensional vortex density
$\delta(x, y)$	$= \frac{\partial z_c}{\partial x}$ (see Fig.1)

δ_j	jet-deflection angle
$\Delta\sigma$	step length defined by Eq.(41)
θ	angular coordinate (see Eq.(22))
Λ	sweep angle
λ	taper ratio
λ_1, λ_2	Lagrange multipliers (see Eq.(31))
μ	$= V_o/V_j$
μ'	$= \vec{V}_o \cdot \vec{e} / \vec{V}_j \cdot \vec{e}$
ρ	density
ϕ	angular coordinate (see Eq.(29))
$\bar{\phi}$	nondimensional perturbation velocity potential

Subscripts

a	additional
c	control point (see Eq.(1))
j	jet flow
jj	jet flow perturbation due to jet vortices
JJ	jet control points being influenced by jet vortices
JW	jet control points being influenced by wing vortices
o	outer flow
oj	external flow perturbation due to jet vortices
w	wing
v	vortex point (see Eq.(3))
wa	additional wing vortices
wj	perturbation due to wing in jet flow
wo	perturbation due to wing in outer flow
w _o	wing alone vortices
∞	free stream

2. INTRODUCTION

It is well known that the induced drag of the conventional wing is minimized if the span loading is elliptical. In the early of this century, Munk (Ref. 1) developed a theory for minimizing the induced drag of arbitrary lifting configurations. According to the Munk theory, all loadings are assumed light so that the velocity perturbations are small and the wake in the Trefftz plane may be assumed undistorted. Later, Mangler (Ref. 2) studied the relationship of the circulation distribution over the wing and of the lift to the height of end plate. In his theory, an infinitely thin flat plate was assumed. The theoretical elliptical loading was obtained when the end plate has zero height. For the same problem, Cone (Ref. 3) experimentally determined the optimum spatial distribution of vorticity, corresponding to the minimum induced drag for a specified lift and a given configuration. He used the analogy of a velocity potential and an electrical potential in a medium of uniform conductivity. Lundry (Ref. 4) developed a procedure for accurate computation of the minimum induced drag of nonplanar wings with pylon-like panels. This method was restricted to a two-dimensional Trefftz plane so that the Schwartz-Christoffel transformation can be used. Stevens (Ref. 5) investigated the suitability of planar lifting surface theory to high lift wing design. In his theory the optimal camber surface of the wing is obtained by constraining the spanwise lift distribution to be elliptic. Loth (Ref. 6) determined the optimal span loading on bent lifting lines in the Trefftz plane. Lamar (Ref. 7) used the Vortex-Lattice Method to determine the optimal span loading for minimum drag for interacting surfaces, and to solve the mean camber surface of the wing which will provide the required loading.

In the above references, it was seen that different methods were used to find the minimum induced drag configuration for the conventional wings. They include the lifting line theory, the vortex lattice method, the Kernel function method (Ref. 8), etc. However, one common feature of these methods is that the span loading shape must be prescribed in advance. For the present investigation of configurations with jet interaction, this is not possible.

The main purposes of this investigation are therefore as follows:

(1) to develop a new method to determine the optimum camber surface and twist distribution for the minimum induced drag in the wing-alone case without prescribing the span loading shape; (2) and to use the same method to find the corresponding minimum induced drag configuration with the upper-surface-blowing jet. In both cases, the optimum configurations are computed under constraints of specified lift and pitching moment. Lan's method (Ref. 9) and his formulation for the upper-surface-blowing problem will be used in the investigation.

3. THEORETICAL DEVELOPMENT

In the present analysis, the thin wing in the linear inviscid subsonic compressible flow will be assumed. Therefore, the assumption of small angle of attack, flap deflection, thickness ratio, and camber is applicable. The expressions of induced drag, lift and pitching moment coefficients can therefore be simplified. The near-field method is used here to predict the aerodynamic characteristics of wings under jet-off and jet-on conditions. In section 3.1 the boundary conditions in wing-alone and jet-on cases will be described. In section 3.2 the simplified formula of the sectional aerodynamic coefficients will be derived. In section 3.3 the overall aerodynamic characteristics are determined by spanwise integration of the sectional characteristics. In section 3.4 a method is presented to find the optimum wing-alone and jet-on vortex strengths. In section 3.5 the camber ordinates and local angle of attack are determined by integrating the camber slope in the chordwise direction. The detailed procedures of iteration are summarized in section 3.6.

3.1 Boundary Conditions and Interpolation Matrix

In the wing-jet interaction theory described in Refs. 10 and 11, the solution is obtained by solving the wing-alone case first and then the additional effect due to jet interaction. To set up all the influence coefficient matrices, the Quasi-Vortex-Lattice method (Ref. 9) is used in the computation. In the wing-alone case, there is only one boundary condition - wing flow tangency condition, to be satisfied. It can be written as :

$$\begin{bmatrix} N_{WW} \end{bmatrix} \begin{Bmatrix} \gamma_{w_0} \end{Bmatrix} = \begin{Bmatrix} \frac{\partial z_c}{\partial x} - \alpha \end{Bmatrix}_c \quad (1)$$

where $\left\{ \frac{\partial z_c}{\partial x} - \alpha \right\}_c$ are the camber slopes at the control points. Since the camber slopes at the vortex points are needed in the computation of the induced drag coefficient, it is necessary to interpolate the values at the control points. The trigonometric interpolation formula derived in Ref. 12 is suitable for this purpose.

$$\left(\frac{\partial z_c}{\partial x_i} - \alpha \right) = \sum_{k=1}^N \left(\frac{\partial z_c}{\partial x_k} - \alpha \right) \left(\frac{(-1)^{1+k} \sin \theta_k}{\cos \theta_k - \cos \theta_1} \right) \quad (2)$$

where the indices k and i represent the corresponding vortex and control points respectively. In matrix form, Eq. (2) becomes:

$$\left\{ \frac{\partial z_c}{\partial x} - \alpha \right\}_c = \begin{bmatrix} I \end{bmatrix} \left\{ \frac{\partial z_c}{\partial x} - \alpha \right\}_v \quad (3)$$

where $\begin{bmatrix} I \end{bmatrix}$ is the interpolation matrix. Thus,

$$\left\{ \frac{\partial z_c}{\partial x} - \alpha \right\}_v = \begin{bmatrix} I \end{bmatrix}^{-1} \left\{ \frac{\partial z_c}{\partial x} - \alpha \right\}_c \quad (4)$$

or,

$$\begin{aligned} \left\{ \frac{\partial z_c}{\partial x} - \alpha \right\}_v &= \begin{bmatrix} I \end{bmatrix}^{-1} \begin{bmatrix} N_{WW} \end{bmatrix} \left\{ \gamma_{w_0} \right\} \\ &= \begin{bmatrix} A \end{bmatrix} \left\{ \gamma_{w_0} \right\} \end{aligned} \quad (5)$$

In the jet-on case, there are three boundary conditions to be satisfied:

1) Pressure continuity on the jet surface

$$\begin{bmatrix} S_{JJ} \end{bmatrix}_{(j)} \left\{ \gamma_{jj} \right\} - T(\mu')^2 \begin{bmatrix} S_{JJ} \end{bmatrix}_{(o)} \left\{ \gamma_{oj} \right\} - T(\mu')^2 \begin{bmatrix} S_{JW} \end{bmatrix}_{(o)} \left\{ \gamma_{wa} \right\}$$

$$= \left\{ -\frac{\partial \bar{\phi}_{wj}}{\partial s} + T(\mu')^2 \frac{\partial \bar{\phi}_{wo}}{\partial s} \right\} \quad (6)$$

2) Flow tangency on the jet surface

$$\begin{aligned} & -\left[N_{JJ} \right]_{(j)} \left\{ \gamma_{jj} \right\} + \left[N_{JJ} \right]_{(o)} \left\{ \gamma_{oj} \right\} + \left[N_{JW} \right]_{(o)} \left\{ \gamma_{wa} \right\} \\ & = \left\{ -\frac{\vec{V}_o \cdot \vec{n}(1-\mu')}{\vec{V}_o \cdot \vec{e}} + \frac{\partial \bar{\phi}_{wj}}{\partial n} (M_j) - \frac{\partial \bar{\phi}_{wo}}{\partial n} (M_o) \right\} \end{aligned} \quad (7)$$

3) Flow tangency on the wing surface

$$\left[N_{WJ} \right]_{(o)} \left\{ \gamma_{oj} \right\} + \left[N_{WW} \right] \left\{ \gamma_{wa} \right\} = \left\{ -\frac{\vec{v}_{je} \cdot \vec{k}}{V_\infty \cos \alpha} \right\} \quad (8)$$

Equations (6), (7) and (8) have been combined into an augmented matrix equation to determine γ_{jj} , γ_{oj} and γ_{wa} . Once γ_{wa} is obtained, the total wing vortex strength is then,

$$\gamma_w = \gamma_{w_o} + \gamma_{wa} \quad (9)$$

where γ_{w_o} is the wing-alone vortex strength and γ_{wa} is the additional wing vortex strength.

3.2 Sectional Aerodynamic Coefficients

From the geometry of the mean camber line (Fig. 1), the relation of the local camber slope, twist, lift and induced drag have the following relations with the wing vortex strength. Since,

$$\frac{\partial z_c}{\partial x} = \tan \delta(x,y) \approx \delta(x,y) \quad (10)$$

the local lift and induced drag components due to the vortex strength are seen to be

$$l(x) = \gamma_w(x) \cos(\alpha - \delta(x,y)) \quad (11)$$

$$d_i(x) = \gamma_w(x) \sin(\alpha - \delta(x,y)) \quad (12)$$

where $\gamma_w(x)$ is the vortex strength and is proportional to the pressure loading acting normal to the camber surface.

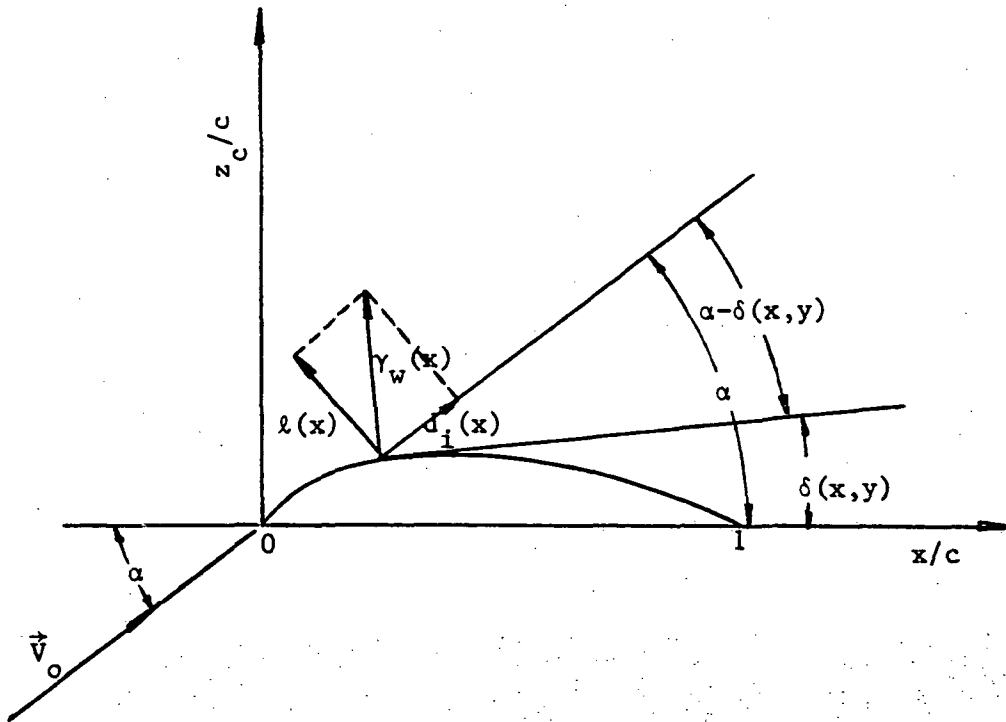


Figure 1. Decomposition of Pressure Loading on the
Camber Surface

The effect of the leading-edge suction on the lift and pitching moment is assumed small enough to be ignored. It is assumed that the wing camber will be designed in such a way that the leading-edge suction is zero.

To find the sectional characteristics, it is assumed that the wing vortices are situated along the camber surface. Since the resulting pressure force is normal to the camber surface, the sectional characteristics can be determined by integrating Eqs. (11) and (12) across the local chord. Thus,

$$\begin{aligned}
 c_{d,i} &= \frac{1}{q_0 c} \int_0^1 \rho_0 V_0 (\vec{V}_0 \cdot \vec{e}) d_1(x) dx \\
 &= \frac{2 \cos \alpha}{c} \int_0^1 \gamma_w(x) \sin(\alpha - \delta(x, y)) dx \\
 &\approx \frac{2}{c} \left(\int_0^{x_1} + \int_{x_1}^1 \right) \gamma_w(x) \sin(\alpha - \delta(x, y)) dx \quad (13)
 \end{aligned}$$

where $\cos \alpha \approx 1$. The integration in Eq. (13) will first be transformed to an angular coordinate θ ($0 \leq \theta \leq \pi$) and then reduced to a finite sum by using the conventional trapezoidal rule. Then, Eq. (13) becomes

$$\begin{aligned}
 c_{d,i} &\approx \frac{2}{c} \left(\frac{x_1 \pi}{2N_1} \sum_{k=1}^{N_1} \gamma_{w_k} \sin(\alpha - \delta(x, y)) \sin \theta_k + \right. \\
 &\quad \left. \frac{(1-x_1)\pi}{2N_2} \sum_{k=1}^{N_2} \gamma_{w_k} \sin(\alpha - \delta(x, y)) \sin \theta_k \right) \quad (14)
 \end{aligned}$$

Similarly,

$$\begin{aligned}
c_\ell &= \frac{1}{q_o c} \int_0^1 \rho_o v_o (\vec{V}_o \cdot \vec{e}) \ell(x) dx \\
&= \frac{2}{c} \int_0^1 \gamma_w(x) \cos(\alpha - \delta(x, y)) dx \\
&= \frac{2}{c} \left(\int_0^{x_1} + \int_{x_1}^1 \right) \gamma_w(x) \cos(\alpha - \delta(x, y)) dx \\
&\approx \frac{2}{c} \left(\frac{x_1 \pi}{2N_1} \sum_{k=1}^{N_1} \gamma_{w_k} \cos(\alpha - \delta(x, y)) \sin \theta_k + \right. \\
&\quad \left. \frac{(1-x_1)\pi}{2N_2} \sum_{k=1}^{N_2} \gamma_{w_k} \cos(\alpha - \delta(x, y)) \sin \theta_k \right) \quad (15)
\end{aligned}$$

and,

$$\begin{aligned}
c_m &= \frac{1}{q_o c \bar{c}} \int_0^1 \rho_o v_o (\vec{V}_o \cdot \vec{e}) \ell(x) x dx \\
&= \frac{2}{c \bar{c}} \left(\int_0^{x_1} + \int_{x_1}^1 \right) \gamma_w(x) \cos(\alpha - \delta(x, y)) x dx \\
&\approx \frac{2}{c \bar{c}} \left(\frac{x_1 \pi}{2N_1} \sum_{k=1}^{N_1} \gamma_{w_k} \cos(\alpha - \delta(x, y)) x_k \sin \theta_k + \right. \\
&\quad \left. \frac{(1-x_1)\pi}{2N_2} \sum_{k=1}^{N_2} \gamma_{w_k} \cos(\alpha - \delta(x, y)) x_k \sin \theta_k \right) \quad (16)
\end{aligned}$$

From thin wing theory, $(\alpha - \delta(x,y))$ is assumed to be sufficiently small, so that,

$$\cos(\alpha - \delta(x,y)) \approx 1 \quad (17)$$

$$\begin{aligned} \sin(\alpha - \delta(x,y)) &\approx (\alpha - \delta(x,y)) \\ &\approx \left(\alpha - \frac{\partial z_c}{\partial x} \right) \\ &= - \left(\frac{\partial z_c}{\partial x} - \alpha \right) \end{aligned} \quad (18)$$

Therefore, from Eqs. (17) and (18), the Eqs. (14), (15), and (16) may be recast into the following simple expressions,

$$\begin{aligned} c_{d,i} &= - \frac{\pi}{c} \left(\frac{x_1}{N_1} \sum_{k=1}^{N_1} \gamma_{w_k} \left(\frac{\partial z_c}{\partial x} - \alpha \right)_k \sin \theta_k + \right. \\ &\quad \left. - \frac{(1-x_1)}{N_2} \sum_{k=1}^{N_2} \gamma_{w_k} \left(\frac{\partial z_c}{\partial x} - \alpha \right)_k \sin \theta_k \right) \\ &= - \frac{\pi}{c} \sum_{L=1}^2 \frac{h_L}{N_L} \sum_{k=1}^{N_L} \gamma_{w_k} \left(\frac{\partial z_c}{\partial x} - \alpha \right)_k \sin \theta_k \end{aligned} \quad (19)$$

$$c_l = \frac{\pi}{c} \sum_{L=1}^2 \frac{h_L}{N_L} \sum_{k=1}^{N_L} \gamma_{w_k} \sin \theta_k \quad (20)$$

$$c_m = \frac{\pi}{cc} \sum_{L=1}^2 \frac{h_L}{N_L} \sum_{k=1}^{N_L} \gamma_{w_k} x_k \sin \theta_k \quad (21)$$

where $h_1 = x_1$ and $h_2 = 1-x_1$, and N_1 and N_2 are the numbers of vortex points in each section along the chordwise direction. The control and vortex points are defined as follows, (see Fig. 2a)

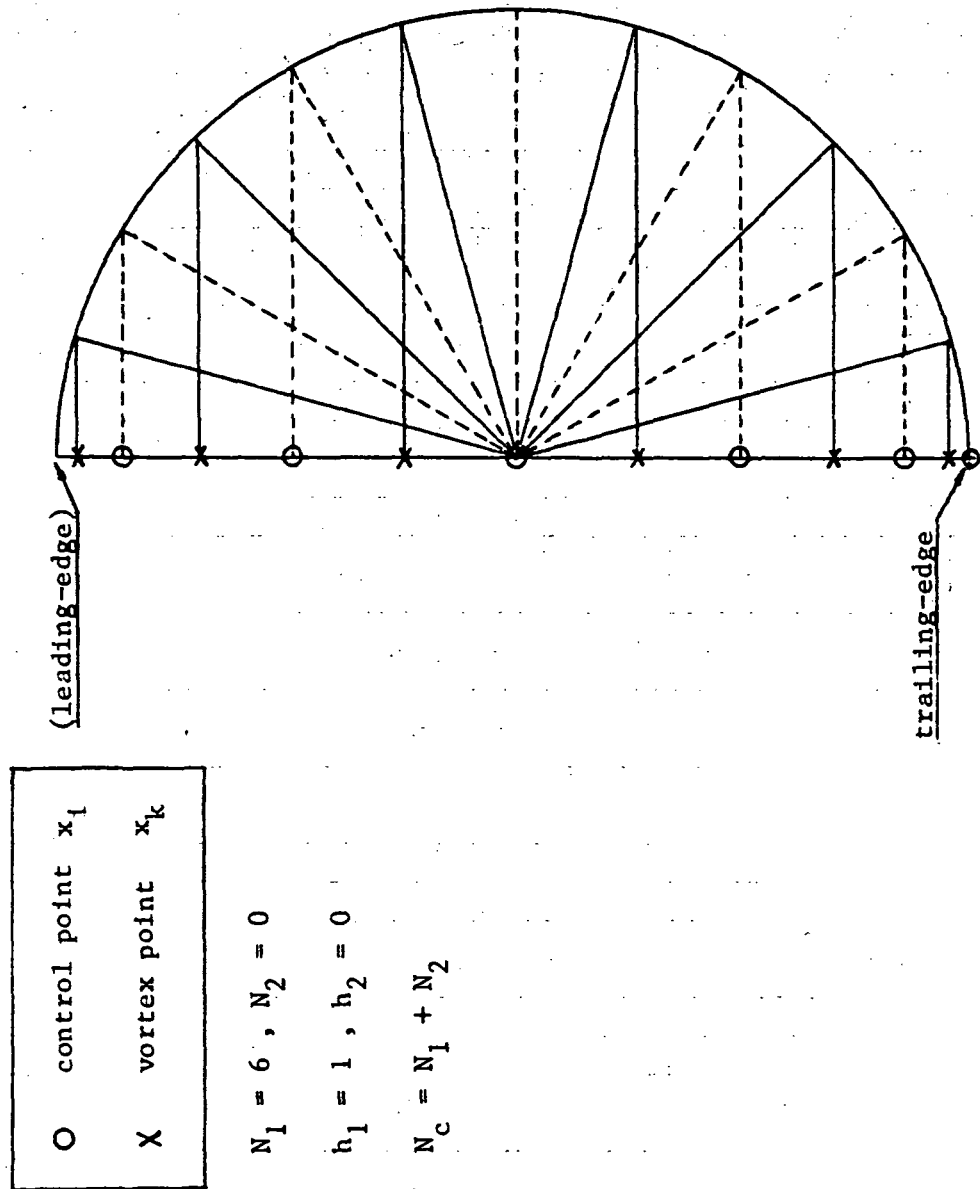


Figure 2a. Location of Control and Vortex Points in the chordwise direction.

$$x_k = x_{L-1} + \frac{h_L}{2} (1 - \cos \theta_k) \quad , \quad L=1,2 \quad (22)$$

$$\theta_k = \frac{(2k-1)\pi}{2N_L} \quad , \quad k=1,2,\dots,N_L \quad (23)$$

and,

$$x_i = x_{L-1} + \frac{h_L}{2} (1 - \cos \theta_i) \quad , \quad L=1,2 \quad (24)$$

$$\theta_i = \frac{i\pi}{N_L} \quad , \quad i=1,\dots,N_L \quad (25)$$

Note that $x_0 = 0$ in Eqs. (22) and (24).

3.3 Overall Aerodynamic Characteristics

The total induced drag, lift and pitching moment coefficients of the wing are determined by spanwise integration of the sectional characteristics. Again, the integration is first transformed to an angular coordinate ϕ ($0 \leq \phi \leq \pi$), and then reduced to finite sums by the conventional trapezoidal rule. Therefore, the total induced drag coefficient has the following expression,

$$\begin{aligned} C_{D,i} &= \frac{1}{S_w} \int_{-b/2}^{b/2} c_{d,i} c \, dy \\ &= \frac{2}{S_w} \int_0^{b/2} c_{d,i} c \, dy \\ &= \frac{-2\pi}{S_w} \int_0^{b/2} \left(\sum_{L=1}^2 \frac{h_L}{N_L} \sum_{k=1}^{N_L} \gamma_{wk} \left(\frac{\partial z_c}{\partial x} - \alpha \right)_k \sin \theta_k \right) dy \end{aligned}$$

$$\begin{aligned}
C_{D,i} &= \frac{-2\pi}{S_w} \left(\int_0^{y_1} + \int_{y_1}^{y_2} + \int_{y_2}^1 \right) \left(\sum_{L=1}^2 \frac{h_L}{N_L} \sum_{k=1}^{N_L} \gamma_{w_k} \left(\frac{\partial z_c}{\partial x} - \alpha \right)_k \sin \theta_k \right) dy \\
&= \frac{-2\pi}{S_w} \left\{ \left[\frac{y_1 \pi}{2M_1} \sum_{i=1}^{M_1-1} \left(\sum_{L=1}^2 \frac{h_L}{N_L} \sum_{k=1}^{N_L} \gamma_{w_k} \left(\frac{\partial z_c}{\partial x} - \alpha \right)_k \sin \theta_k \right) \sin \phi_i \right] + \right. \\
&\quad \left[\frac{(y_2 - y_1) \pi}{2M_2} \sum_{i=1}^{M_2-1} \left(\sum_{L=1}^2 \frac{h_L}{N_L} \sum_{k=1}^{N_L} \gamma_{w_k} \left(\frac{\partial z_c}{\partial x} - \alpha \right)_k \sin \theta_k \right) \sin \phi_i \right] + \\
&\quad \left. \left[\frac{(b/2 - y_2) \pi}{2M_3} \sum_{i=1}^{M_3-1} \left(\sum_{L=1}^2 \frac{h_L}{N_L} \sum_{k=1}^{N_L} \gamma_{w_k} \left(\frac{\partial z_c}{\partial x} - \alpha \right)_k \sin \theta_k \right) \sin \phi_i \right] \right\} \\
&= \frac{-\pi^2}{S_w} \left\{ \sum_{p=1}^3 \frac{f_p}{M_p} \sum_{i=1}^{M_p-1} \left(\sum_{L=1}^2 \frac{h_L}{N_L} \sum_{k=1}^{N_L} \gamma_{w_k} \left(\frac{\partial z_c}{\partial x} - \alpha \right)_k \sin \theta_k \right) \sin \phi_i \right\} \\
&= \frac{-\pi^2}{S_w} \left\{ \sum_{p=1}^3 \sum_{i=1}^{M_p-1} \sum_{L=1}^2 \sum_{k=1}^{N_L} \left[\left(\frac{f_p h_L}{M_p N_L} \right) \sin \theta_k \sin \phi_i \right] \left(\frac{\partial z_c}{\partial x} - \alpha \right)_k \gamma_{w_k} \right\} \\
&= - \frac{\pi^2}{S_w} \left(\sum_{n=1}^{N_t} g_n \left(\frac{\partial z_c}{\partial x} - \alpha \right)_n \gamma_{w_n} \right) \tag{26}
\end{aligned}$$

where,

$$g_n = \frac{f_p h_L}{M_p N_L} \sin \theta_n \sin \phi_i \tag{26.a}$$

and it is understood that the indices p , i and L will take proper values at the appropriate spanwise sections and chordwise locations, respectively.

In Eq. (26), N_t is total number of wing vortices over the semi-span, and the width of each spanwise section is :

$$f_1 = y_1 \quad (26.b)$$

$$f_2 = y_2 - y_1 \quad (26.c)$$

$$f_3 = b/2 - y_2 \quad (26.d)$$

Similarly, the lift and pitching moment coefficients have the following expressions,

$$C_L = \frac{\pi^2}{S_w} \left(\sum_{n=1}^{N_t} g_n \gamma_{w_n} \right) \quad (27)$$

$$C_m = \frac{\pi^2}{S_w} \left(\sum_{n=1}^{N_t} g_n x_n \gamma_{w_n} \right) \quad (28)$$

where the index n indicates the corresponding vortex point over the wing.

Each spanwise section is divided into vortex strips by the semi-circle method. The vortex strips in each interval are obtained through the following relation:

$$y_j = y_{p-1} + \frac{f_p}{2} (1 - \cos \phi_j) , p = 1, 2, 3 \quad (29.a)$$

$$\phi_j = (2j - 1)\pi / (2M_p) , j = 1, \dots, M_p \quad (29.b)$$

and y -control points are given by:

$$y_i = y_{p-1} + \frac{f_p}{2} (1 - \cos \phi_i) , p = 1, 2, 3 \quad (30.a)$$

$$\phi_i = i\pi / M_p , i = 1, \dots, M_p - 1 \quad (30.b)$$

Note that $y_0 = 0$ in Eqs. (29.a) and (30.a) . M_1 , M_2 , and M_3 are the numbers of spanwise strips plus one in each section. (see Fig. 2b)

3.4 Optimization Equations

From section 3.3, the expressions of induced drag, lift and pitching moment coefficients have been derived. Next, the method to find the opti-

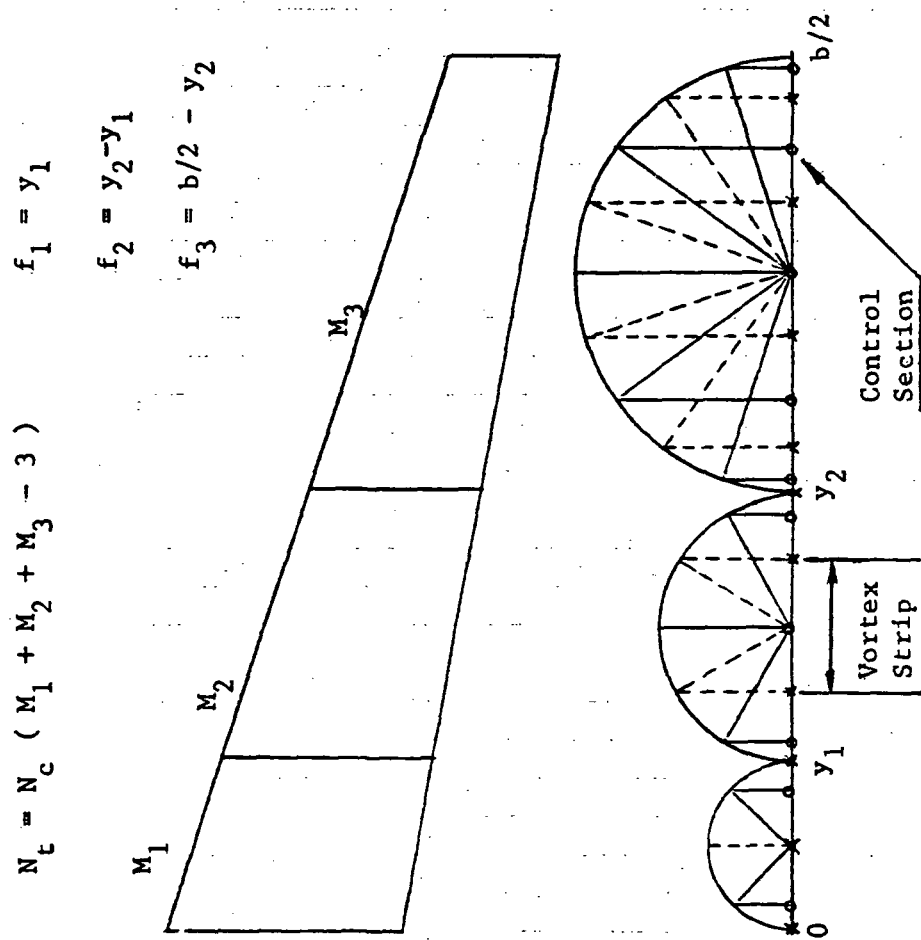


Figure 2b. Scheme of Spanwise Vortex Strip Distribution

mum solution of wing-alone loading such that the induced drag is minimized with the lift and pitching moment constraints will be described. To start the iteration, the wing vortex strengths are at first assumed zero. Then as shown in Appendix A, based on the Method of Gradients (ref. 13), the increment of the wing-alone vortex strength can be determined from the following equations,

$$\Delta\gamma_{w_k} + \lambda_1 \frac{\partial C_L}{\partial \gamma_{w_k}} \Delta\sigma + \lambda_2 \frac{\partial C_m}{\partial \gamma_{w_k}} \Delta\sigma = - \frac{\partial C_{D,i}}{\partial \gamma_{w_k}} \Delta\sigma, \quad (31)$$

$$k=1, \dots, N_t$$

$$\sum_{k=1}^{N_t} \frac{\partial C_L}{\partial \gamma_{w_k}} \Delta\gamma_{w_k} = \bar{C}_L - C_L^{(n)} \quad (32)$$

$$\sum_{k=1}^{N_t} \frac{\partial C_m}{\partial \gamma_{w_k}} \Delta\gamma_{w_k} = \bar{C}_m - C_m^{(n)} \quad (33)$$

where \bar{C}_L and \bar{C}_m are the specified constraints, $C_L^{(n)}$ and $C_m^{(n)}$ are the computed values in the n -th iteration. Therefore, the new vortex density will be given by:

$$\gamma_{w_k}^{(n)} = \gamma_{w_k}^{(n-1)} + \Delta\gamma_{w_k}^{(n)} \quad (34)$$

The optimum solution is obtained as $C_{D,i}$ becomes minimum, or the camber shapes do not change further by any significant amount.

In the wing-alone case, the step size $\Delta\sigma$ can be computed in each iteration by using one-dimensional optimization technique. Differentiating Eqs. (26), (27), and (28) with respect to γ_{w_k} gives the relations,

$$\frac{\partial C_L}{\partial \gamma_{w_k}} = \frac{\pi^2}{S_w} g_k, \quad k=1, \dots, N_t \quad (35)$$

and,

$$\frac{\partial C_m}{\partial \gamma_{w_k}} = -\frac{\pi^2}{S_w} g_k x_k, \quad k=1, \dots, N_t \quad (36)$$

From Eq. (5), the camber slope at vortex point k can be expressed as

$$\left(\frac{\partial z_c}{\partial x} - \alpha \right)_k = \sum_{n=1}^{N_t} a_{kn} \gamma_{w_n} \quad (37)$$

where a_{kn} is the element of matrix $[A]$. It follows that Eq. (26) becomes

$$C_{D,i} = -\frac{\pi^2}{S_w} \left(\sum_{k=1}^{N_t} g_k \gamma_{w_k} \left(\sum_{n=1}^{N_t} a_{kn} \gamma_{w_n} \right) \right) \quad (38)$$

Therefore,

$$\begin{aligned} \frac{\partial C_{D,i}}{\partial \gamma_{w_k}} &= -\frac{\pi^2}{S_w} \left(g_k \sum_{n=1}^{N_t} a_{kn} \gamma_{w_n} + \sum_{i=1}^{N_t} g_i a_{ik} \gamma_{w_i} \right) \\ &= -\frac{\pi^2}{S_w} \left(\sum_{n=1}^{N_t} (g_k a_{kn} + g_n a_{nk}) \gamma_{w_n} \right) \end{aligned} \quad (39)$$

The objective is to find the best step size such that $C_{D,i}$ will decrease in the steepest descent direction. It can be shown by the chain rule

that :

$$\frac{\partial C_{D,i}}{\partial (\Delta \sigma)} = \sum_{k=1}^{N_t} \left(\frac{\partial C_{D,i}}{\partial \gamma_{w_k}} \right) \left(\frac{d \gamma_{w_k}}{d (\Delta \sigma)} \right) \quad (40)$$

Since the new vortex strength and the old vortex strength may be assumed to be :

$$\gamma_{w_k}^{(n+1)} = \gamma_{w_k}^{(n)} + E_k^{(n)} \Delta\sigma, \quad (41)$$

where the step direction vector E_k can be obtained from Eq. (31) to be :

$$E_k = - \left(\frac{\partial C_{D,i}}{\partial \gamma_{w_k}} + \lambda_1 \frac{\partial C_L}{\partial \gamma_{w_k}} + \lambda_2 \frac{\partial C_m}{\partial \gamma_{w_k}} \right), \quad (42)$$

$$k=1, \dots, N_t$$

Substituting Eqs. (39), (41) and (42) into (40) gives :

$$\frac{\partial C_{D,i}}{\partial (\Delta\sigma)} = - \frac{\pi}{S_w} \sum_{k=1}^{N_t} \left(\sum_{n=1}^{N_t} (g_k a_{kn} + g_n a_{nk}) (\gamma_{w_n} + E_n \Delta\sigma) \right) E_k \quad (43)$$

The optimum step size $\Delta\sigma$ can be obtained by setting $\frac{\partial C_{D,i}}{\partial (\Delta\sigma)}$ to zero.

It follows that

$$\Delta\sigma = - \frac{\sum_{k=1}^{N_t} \left(\sum_{n=1}^{N_t} (g_k a_{kn} + g_n a_{nk}) E_n \right) \gamma_{w_k}}{\sum_{k=1}^{N_t} \left(\sum_{n=1}^{N_t} (g_k a_{kn} + g_n a_{nk}) E_n \right) E_k} \quad (44)$$

In the jet-on case, the total wing vortex strength is equal to the sum of the wing-alone vortex strength γ_{w_0} and the additional wing vortex strength γ_{wa} . Therefore, from Eqs. (9), (26), (27) and (28),

$$C_{D,i} = - \frac{\pi}{S_w} \sum_{k=1}^{N_t} g_k \left(\frac{\partial z_c}{\partial x} - \alpha \right)_k (\gamma_{w_0} + \gamma_{wa})_k \quad (45)$$

$$C_L = \frac{\pi^2}{S_w} \sum_{k=1}^{N_t} g_k (\gamma_{w_o} + \gamma_{wa})_k \quad (46)$$

$$C_m = \frac{\pi^2}{S_w} \sum_{k=1}^{N_t} g_k (\gamma_{w_o} + \gamma_{wa})_k x_k \quad (47)$$

In the optimization iteration, γ_{w_o} is regarded as the independent variable. In the optimization Eqs. (31) - (33), the derivatives $\frac{\partial C_L}{\partial \gamma_{w_o}}$, $\frac{\partial C_m}{\partial \gamma_{w_o}}$ and $\frac{\partial C_{D,i}}{\partial \gamma_{w_o}}$ are needed. They can be obtained by differentiating Eqs. (45) - (47) with respect to $\gamma_{w_o k}$. Hence,

$$\frac{\partial C_L}{\partial \gamma_{w_o k}} = \frac{\pi^2}{S_w} \left(g_k + \sum_{i=1}^{N_t} g_i \left(\frac{\partial \gamma_{wa}}{\partial \gamma_{w_o k}} \right)_i \right) \quad (48)$$

$$\frac{\partial C_m}{\partial \gamma_{w_o k}} = \frac{\pi^2}{S_w} \left(g_k x_k + \sum_{i=1}^{N_t} g_i x_i \left(\frac{\partial \gamma_{wa}}{\partial \gamma_{w_o k}} \right)_i \right) \quad (49)$$

From Eqs. (1) and (8), and the interpolation matrix $[I]$, the camber slope at the vortex point k is given by:

$$\left(\frac{\partial z_c}{\partial x} - \alpha \right)_k = \sum_{j=1}^{N_t} a_{kj} (\gamma_{w_o} + \gamma_{wa})_j + \sum_{n=1}^{N_j} b_{kn} \gamma_{oj_n} \quad (50)$$

where N_j is the total number of jet vortices in the outer flow, and a_{kj} and b_{kn} are the elements of the transformation matrices $[A]$ and $[B]$ respectively. From Eqs. (4) and (8), $[A]$ and $[B]$ are defined as

$$[A] = [I]^{-1} [N_{WW}] \quad (50.a)$$

$$[B] = [I]^{-1} [N_{WJ}]_{(o)} \quad (50.b)$$

Differentiate Eq. (50) with respect to $\gamma_{w_o i}$ gives:

$$\begin{aligned} & \frac{\partial}{\partial \gamma_{w_o i}} \left(\frac{\partial z_c}{\partial x} - \alpha \right)_k \\ &= a_{ki} + \sum_{m=1}^{N_t} a_{km} \left(\frac{\partial \gamma_{wa}}{\partial \gamma_{w_o i}} \right)_m + \sum_{n=1}^{N_j} b_{kn} \left(\frac{\partial \gamma_{oj}}{\partial \gamma_{w_o i}} \right)_n \end{aligned} \quad (51)$$

With Eqs. (50) and (51), Eq. (45) gives:

$$\begin{aligned} \frac{\partial C_{D,i}}{\partial \gamma_{w_o i}} = & - \frac{\pi}{S_w} \left\{ g_i \left[\sum_{j=1}^{N_t} a_{ij} (\gamma_{w_o} + \gamma_{wa})_j + \sum_{n=1}^{N_j} b_{in} \gamma_{oj_n} \right] + \right. \\ & \sum_{k=1}^{N_t} g_k \left(\frac{\partial \gamma_{wa}}{\partial \gamma_{w_o i}} \right)_k \left[\sum_{j=1}^{N_t} a_{kj} (\gamma_{w_o} + \gamma_{wa})_j + \sum_{n=1}^{N_j} b_{kn} \gamma_{oj_n} \right] + \\ & \left. \sum_{n=1}^{N_t} g_n (\gamma_{w_o} + \gamma_{wa})_n \left[a_{ni} + \sum_{m=1}^{N_t} a_{nm} \left(\frac{\partial \gamma_{wa}}{\partial \gamma_{w_o i}} \right)_m + \sum_{p=1}^{N_j} b_{np} \left(\frac{\partial \gamma_{oj}}{\partial \gamma_{w_o i}} \right)_p \right] \right\} \end{aligned} \quad (52)$$

Eqs. (48), (49), (51) and (52) will be evaluated in each iteration, because the needed derivatives depend on the values of γ_{w_o} , γ_{wa} and γ_{oj} in the preceeding step.

The derivatives $\frac{\partial \gamma_{wa}}{\partial \gamma_{w_o}}$, $\frac{\partial \gamma_{oj}}{\partial \gamma_{w_o}}$ can be obtained by differentiating Eqs. (6), (7) and (8) with respect to γ_{w_o} and solving the differentiated simultaneous equations.

From numerical experimentation, it was found that the one-dimensional optimization technique in finding the best step size used previously for the wing alone case did not produce consistently converging solutions in the jet-on case. In fact, the rate of convergence depends very much on the jet strength, or on μ . According to the author's experience, the following relation of step size and μ may be used:

$$\Delta\sigma = 3.0864 \mu - 0.39506 \quad (53)$$

The above computed step size is assumed unchanged during iteration for the jet-on case.

3.5 The Determination of Camber Ordinates

Once the optimum solution of the wing vortices has been determined from section 3.4, the camber slope at vortex points over the wing may be found from Eq. (5). This section will describe the method used in finding the camber ordinates from the given camber slope. Let the wing camber slope be developed into Fourier cosine series. Then in each spanwise vortex strip over the wing, the camber slope functions have the following expression,

$$\left(\frac{\partial z_c}{\partial x} - \alpha \right)_k = \sum_{j=1}^{N_c} a_j \cos(j-1)\theta_k \quad (54)$$

and the Fourier coefficients are given by,

$$\begin{aligned} a_1 &= \frac{1}{\pi} \int_0^{\pi} \left(\frac{\partial z_c}{\partial x} - \alpha \right) d\theta \\ &\approx \frac{1}{N_c} \sum_{k=1}^{N_c} \left(\frac{\partial z_c}{\partial x} - \alpha \right)_k \end{aligned} \quad (55)$$

and for $j > 1$,

$$a_j = \frac{2}{\pi} \int_0^{\pi} \left(\frac{\partial z_c}{\partial x} - \alpha \right) \cos(j-1)\theta d\theta$$

$$= \frac{2}{N_c} \sum_{k=1}^{N_c} \left(\frac{\partial z_c}{\partial x} - \alpha \right)_k \cos(j-1)\theta_k \quad (56)$$

$$\text{where } \theta_k = \frac{(2k-1)\pi}{2N_c}, \quad k=1, \dots, N_c \quad (57)$$

Once the Fourier coefficients are determined, the camber ordinates can be obtained by direct integration. For each vortex strip, Eq. (54) is :

$$\left(\frac{\partial z_c}{\partial x} - \alpha \right) = a_1 + a_2 \cos\theta + \dots + a_{N_c} \cos(N_c-1)\theta \quad (58)$$

where N_c is the total number of chordwise vortex elements. By integrating Eq. (58) with respect to x , the camber ordinates along each spanwise vortex strip over the wing can be obtained. Thus,

$$z_c(x) = (\alpha + a_1)x + \int_0^x (a_2 \cos\theta + \dots + a_{N_c} \cos(N_c-1)\theta) dx \quad (59)$$

Since $x = (1 - \cos\theta) / 2$, Eq. (59) becomes

$$z_c(\theta) = (\alpha + a_1)(1 - \cos\theta)/2 + \int_0^\theta (a_2 \cos\theta + \dots + a_{N_c} \cos(N_c-1)\theta) \sin\theta d\theta / 2 \quad (60)$$

From the mathematics handbook (Ref. 15),

$$\int \sin x \cos Nx \, dx = -\frac{1}{2} \left(\frac{\cos(1-N)x}{1-N} + \frac{\cos(1+N)x}{1+N} \right), \quad (61)$$

$$N > 1$$

It follows that Eq. (60) becomes :

$$z_c(\theta) = (\alpha + a_1) (1 - \cos\theta)/2 - a_2 \cos 2\theta/8 - \frac{1}{4} \sum_{n=2}^{N_c-1} \left(\frac{\cos(1+n)\theta}{1+n} + \frac{\cos(1-n)\theta}{1-n} \right) + C_1 \quad (62)$$

where α and C_1 are the local angle of attack and integration constant respectively. They are determined by ends condition. Since $z_c(0) = z_c(\pi) = 0$, from the leading-edge end condition,

$$z_c(0) = -\frac{a_2}{8} - \frac{1}{4} \sum_{n=2}^{N_c-1} a_{n+1} \left(\frac{1}{1+n} + \frac{1}{1-n} \right) + C_1 = 0$$

Hence,

$$C_1 = \frac{a_2}{8} + \frac{1}{4} \sum_{n=2}^{N_c-1} a_{n+1} \left(\frac{1}{1+n} + \frac{1}{1-n} \right) \quad (63)$$

From the trailing-edge end condition,

$$z_c(\pi) = (\alpha + a_1) - \frac{a_2}{8} - \frac{1}{4} \sum_{n=2}^{N_c-1} a_{n+1} \left(\frac{\cos(1-n)\pi}{1-n} + \frac{\cos(1+n)\pi}{1+n} \right) + C_1 = 0$$

Hence, the local angle of attack is given by :

$$\alpha = \frac{1}{4} \sum_{n=2}^{N_c-1} a_{n+1} \left(\frac{\cos(1-n)\pi-1}{1-n} + \frac{\cos(1+n)\pi-1}{1+n} \right) - a_1 \quad (64)$$

Finally, the camber ordinates along each spanwise vortex strip are determined by,

$$\begin{aligned}
z_c(\theta) = & \left[\frac{1}{4} \sum_{n=2}^{N-1} a_{n+1} \left(\frac{\cos(1-n)\pi-1}{1-n} + \frac{\cos(1+n)\pi-1}{1+n} \right) \right] \left(\frac{1-\cos\theta}{2} \right) - \\
& \frac{a_2}{8} \cos 2\theta - \frac{1}{4} \sum_{n=2}^{N-1} \left(\frac{\cos(1-n)\theta}{1-n} + \frac{\cos(1+n)\theta}{1+n} \right) + \\
& \frac{a_2}{8} + \frac{1}{4} \sum_{n=2}^{N-1} a_{n+1} \left(\frac{1}{1-n} + \frac{1}{1+n} \right) \quad (65)
\end{aligned}$$

3.6 Summary of Solution Procedures

In the jet-off case, the basic unknowns to be determined are the wing-alone vortex strengths. The problem is solved by the iterative process described below :

1. Assume all the initial wing-alone vortex strengths are zero and the initial step size has some value, typically 50.
2. By solving the optimization equations, i.e., Eqs. (31) - (33), the new wing-alone vortex strengths are determined.
3. Calculate the camber slope at the vortex points from Eq. (5) and compute the aerodynamic characteristics.
4. Check the convergence of the induced drag coefficient and adjust the computed step size if necessary.
5. Compute the new step size by using one-dimensional optimization technique.
6. Repeat steps 2 through 5 until a converged solution is obtained.

7. Calculate the camber ordinates, local angles of attack and the optimum loading.

In the jet-on case, the value of additional wing vortex strengths depend on the value of wing-alone vortex strengths in each iteration.

Therefore, the approach to find the optimum solution is described below;

1. Invert the augmented matrix of the boundary conditions, i.e., Eqs. (6) - (8).
2. Calculate the derivatives of the jet vortex strength in the outer flow and the additional wing vortex strength with respect to wing-alone vortex strength from the differentiated equations of Eq. (6), (7) and (8).
3. Set up the transformation matrices from Eqs. (50.a) and (50.b).
4. Compute the derivatives of the camber slopes at the vortex points with respect to the wing-alone vortex strength, i.e., Eq. (51).
5. Assume the initial wing-alone vortex strengths equal to the optimum loading which were found in the jet-off case.
6. By solving the optimization equations and varying the initial computed lift and pitching moment coefficients to the constrained values gradually, the new wing-alone vortex strengths can be obtained.
7. Calculate the camber slopes at vortex points from Eq. (50).
8. Use the new wing-alone vortex strengths to determine the right hand sides of Eqs. (6) - (8).
9. Calculate the jet vortex strengths in the outer flow and the additional wing vortex strengths by the results of steps 1 and 8.
10. Compute the total wing vortex strengths and the aerodynamic characteristics.

11. Once the computed lift and pitching moment coefficients achieve the constrained values, check the induced drag coefficient and adjust the assumed step size if necessary. Finally, calculate the camber ordinates, local angles of attack and the corresponding loading.
12. Check the changes in camber ordinates in consecutive iterations.
13. Assume a constant step size for each iteration, the step size being determined by the empirical formula of Eq.(53).
14. Repeat steps 6 through 13 until the desired solution is obtained.

It should be noted that in the first iteration, steps 6 and 7 are to be omitted. From the assumed wing-alone vortex strengths, the initial computed lift and pitching moment coefficients are determined.

To have a smooth transition in the entire iterative process, the initial computed lift and pitching moment coefficients will be varying through several intermediate cycles, and each cycle includes two or three iterations. Since the solution is very sensitive to the variation of the step size, the computed step size by one-dimensional optimization technique is not used. A reasonable step size in the entire iterative process should be such that the induced drag coefficient keeps decreasing as the specified constraints were reached.

4. NUMERICAL RESULTS AND DISCUSSIONS

A highly swept back tapered wing (NACA 64A010 uncambered) has been selected for analysis to check out the program and illustrate its application. The basic geometries of the planform are: (1) aspect ratio of 5.5; (2) taper ratio of 0.532; (3) sweep back angle at quarter chord of 45° . In the wing-alone case, all the results have been calculated by using six chordwise vortex elements and ten spanwise vortex strips over the semi-span of the wing. The geometry is shown in Fig. 3. In the jet-on case, the semi-span of the wing is divided into three sections, and there are three vortex strips inside the jet region. The length of trailing jet c_j used in the analysis was one local chord length and four trailing vortices in the computation. The jet exit is at the leading-edge.

The computed induced drag coefficient in the jet-off case approaches the theoretical minimum induced drag coefficient in about 10 iterations, as shown in Fig. 4. The speed of convergence depends on the absolute value of the computed step size. The solution is assumed to have converged if the difference between the computed induced drag coefficient and the theoretical minimum induced drag coefficient is less than five percent. With the wing design lift coefficient being 0.6 and the design pitching moment coefficient being -0.036 , an iterative process is then used to derive the optimum camber and the local angle of attack distributions. Calculated mean camber ordinates and pressure distributions are compared with Stevens' (Ref. 5) theoretical results by the Kernel function method (Ref. 8) for three spanwise stations in Figs. 5 - 6. The agreement is seen to be reasonably good. It should be noted that to make the comparison at the same spanwise locations with Stevens' results, Lagrange interpolation technique is used here to find:

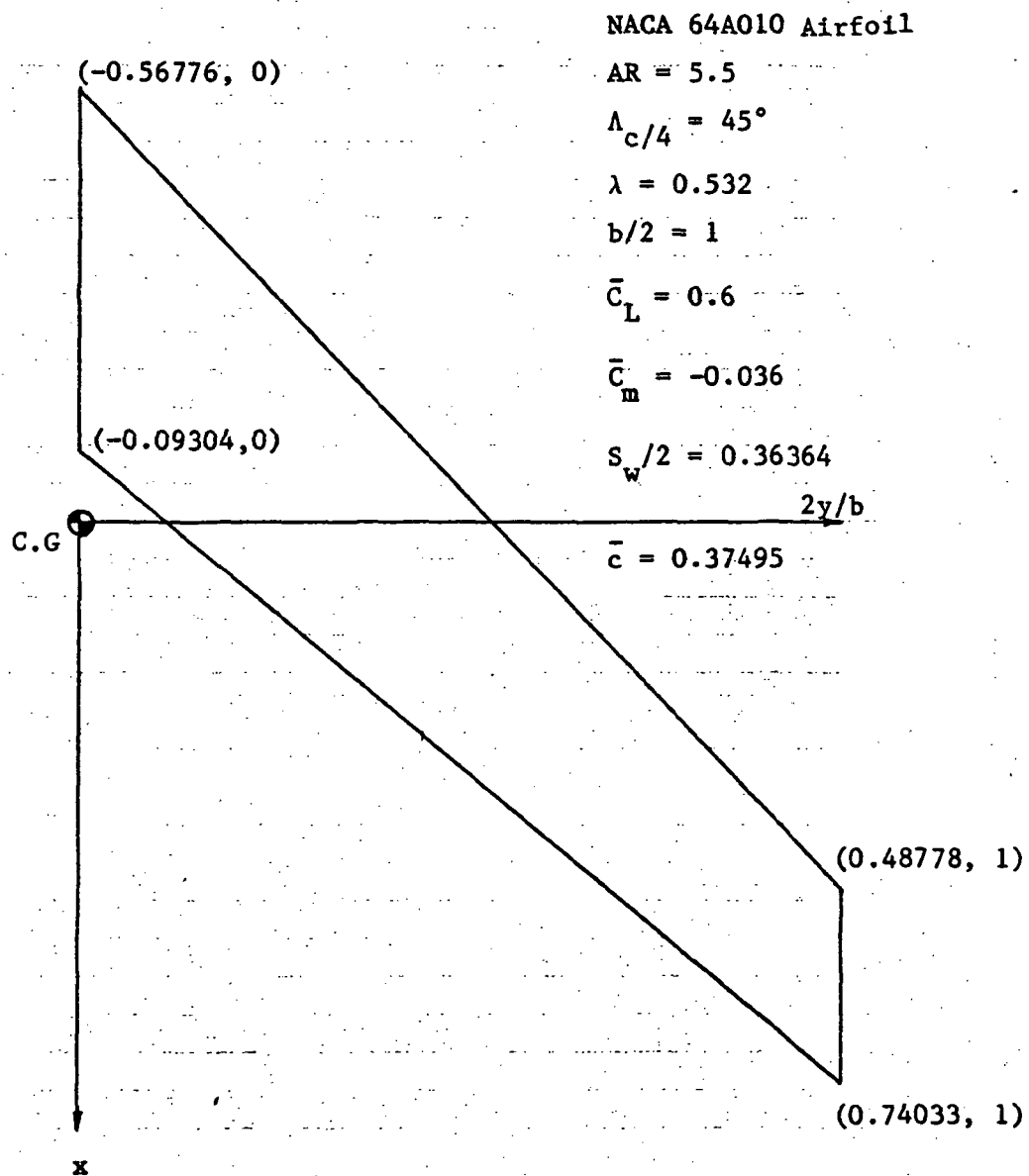


Figure 3. Geometry of Wing Planform in the jet-off case.

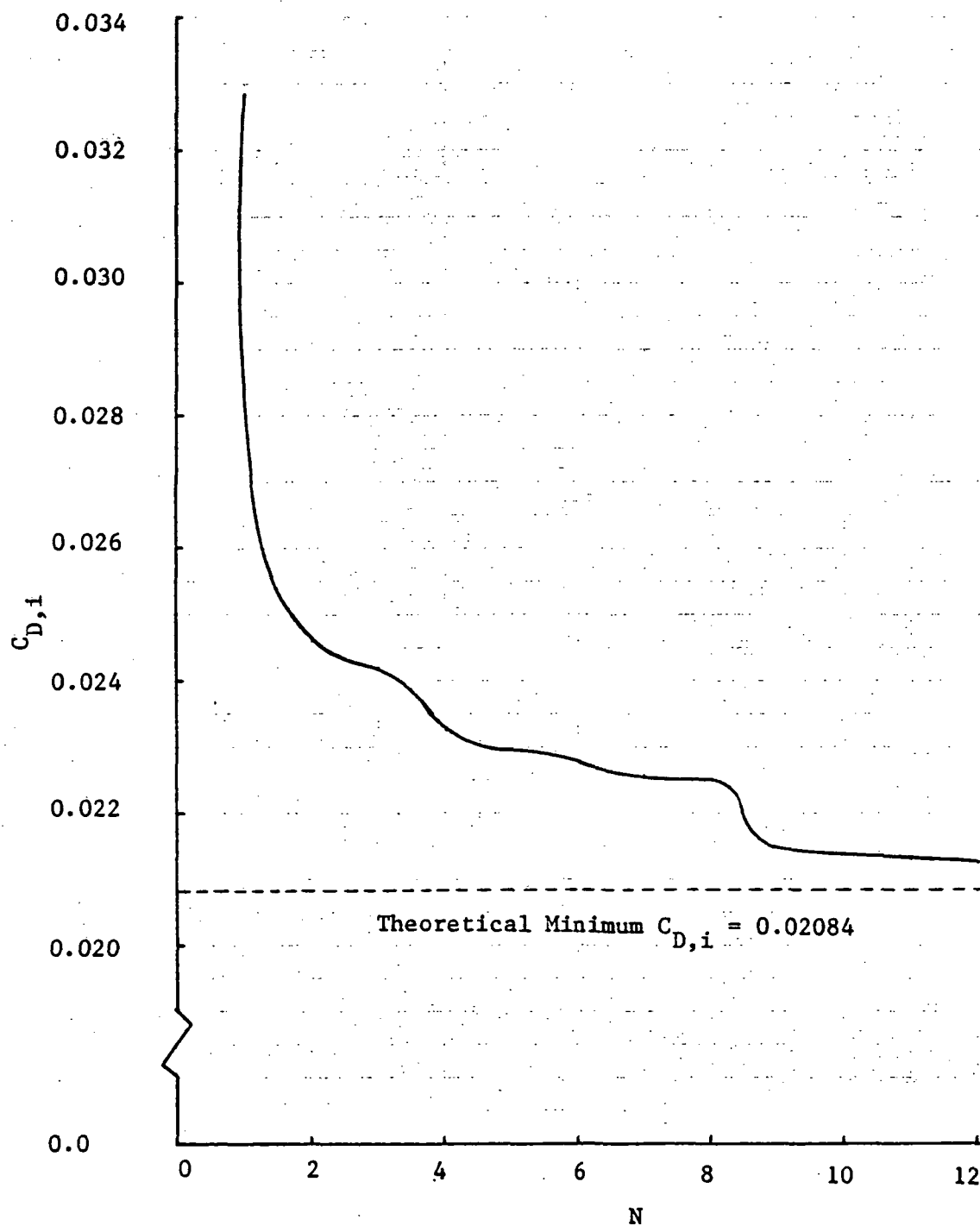


Figure 4. Convergence of Induced Drag Coefficient vs number of iterations in the jet-off case.

AR= 5.5, $\bar{C}_L = 0.6$, $\bar{C}_m = -0.036$

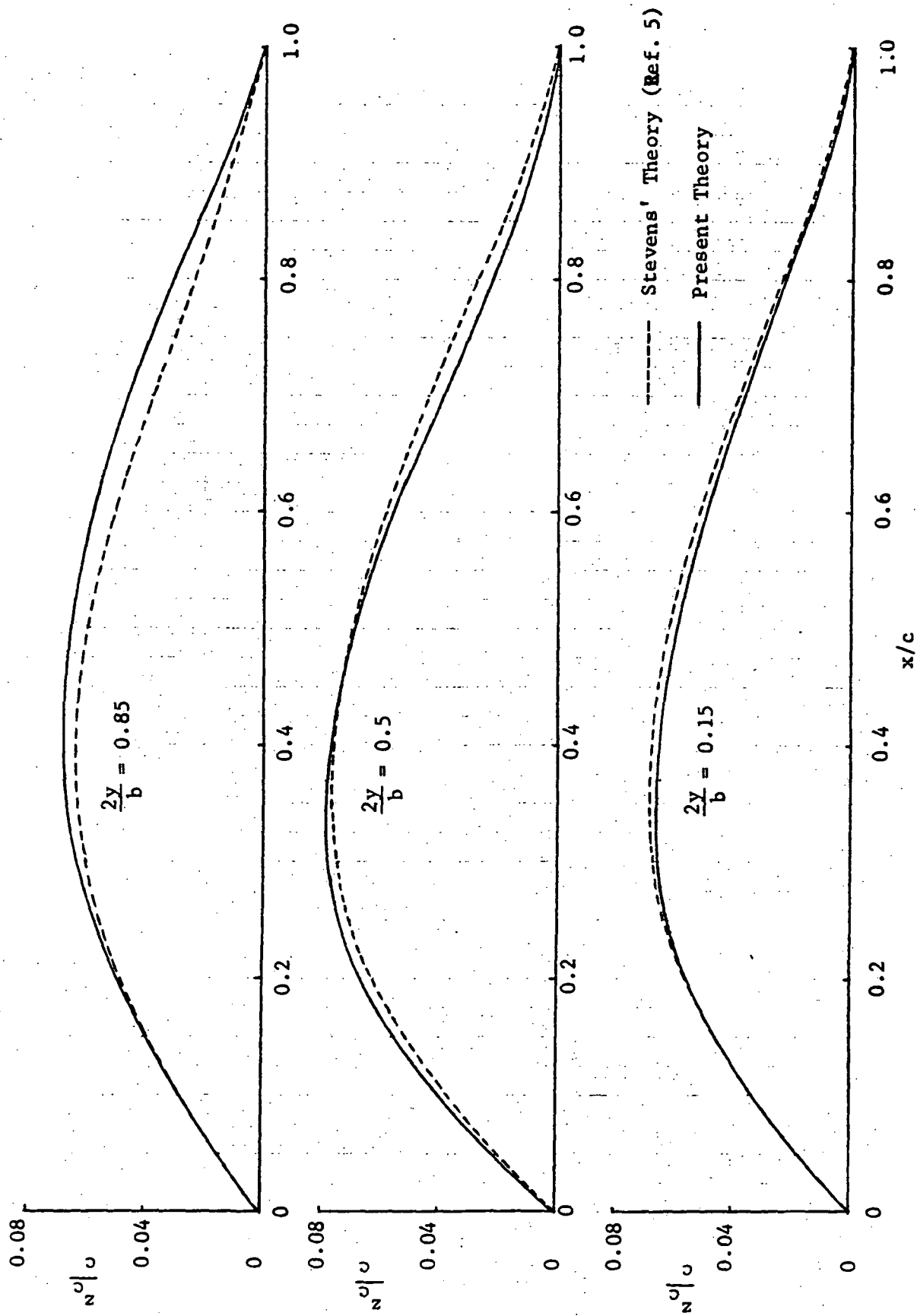


Figure 5. Mean Camber Shape in the jet-off case. ($\bar{C}_L = 0.6$, $\bar{C}_m = -0.036$, $\alpha = 0^\circ$)

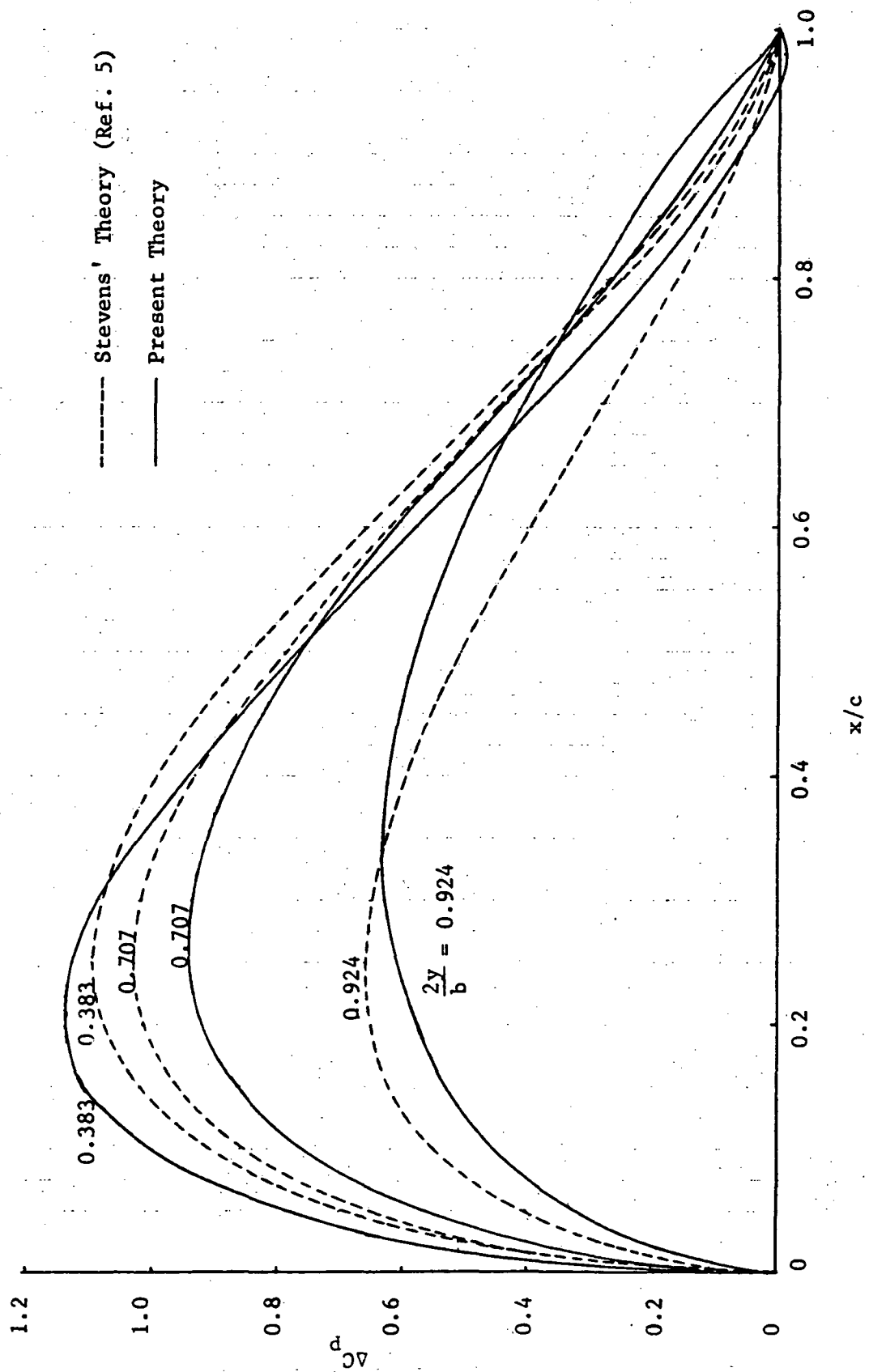


Figure 6. Pressure Distribution in the jet-off case. ($\bar{C}_L = 0.6$, $\bar{C}_m = -0.036$, $\alpha = 0^\circ$)

(1) the calculated mean camber ordinates at spanwise stations of 0.15, 0.5 and 0.85 ; and (2) the computed pressure distribution at spanwise stations of 0.383, 0.707 and 0.924. The comparison of the local angles of attack (or twist) is shown in Fig.7. The agreement is again good. Near the root chord, the computed twist by the present method is seen to be quite nonlinear. This result is consistent with the swept wing design by Williams and Ross in Ref. 16. It is probably due to the planform kink effect . This kink effect seems to appear also in the calculated span loading by the present method, as shown in Fig. 8.

Having established the accuracy for the present method in the wing-alone case, it is of interest to see the minimum induced drag configuration with upper-surface-blowing jet. The geometry is shown in Fig. 9. To show the jet effects, two areas of interest will be investigated. First, how the wing-alone results will be modified by the blowing jet with given μ and δ_j . Second, what the effects of μ and δ_j would have on the camber ordinates, span loading, twist and pressure distribution. All the results are indicated in Figs.10-16. In the jet-on case, the design circulation lift coefficient is 1.2 and the design pitching moment coefficient is -0.075. The calculated camber ordinates at two spanwise stations outside the jet region are shown in Fig.10. It is seen that the mean camber lines are changed significantly in the jet-on case. How they are changed depends on whether they are inside or outside the jet region. The results in Fig. 10 are for $\mu = 0.1288$ and hence are for low speed and high thrust conditions. Also , as indicated in Fig. 10, the δ_j effect on the mean camber is very small. Inside the jet region the camber ordinates at two spanwise stations are shown in Fig. 11. It is seen that under high thrust conditions, the camber in the jet

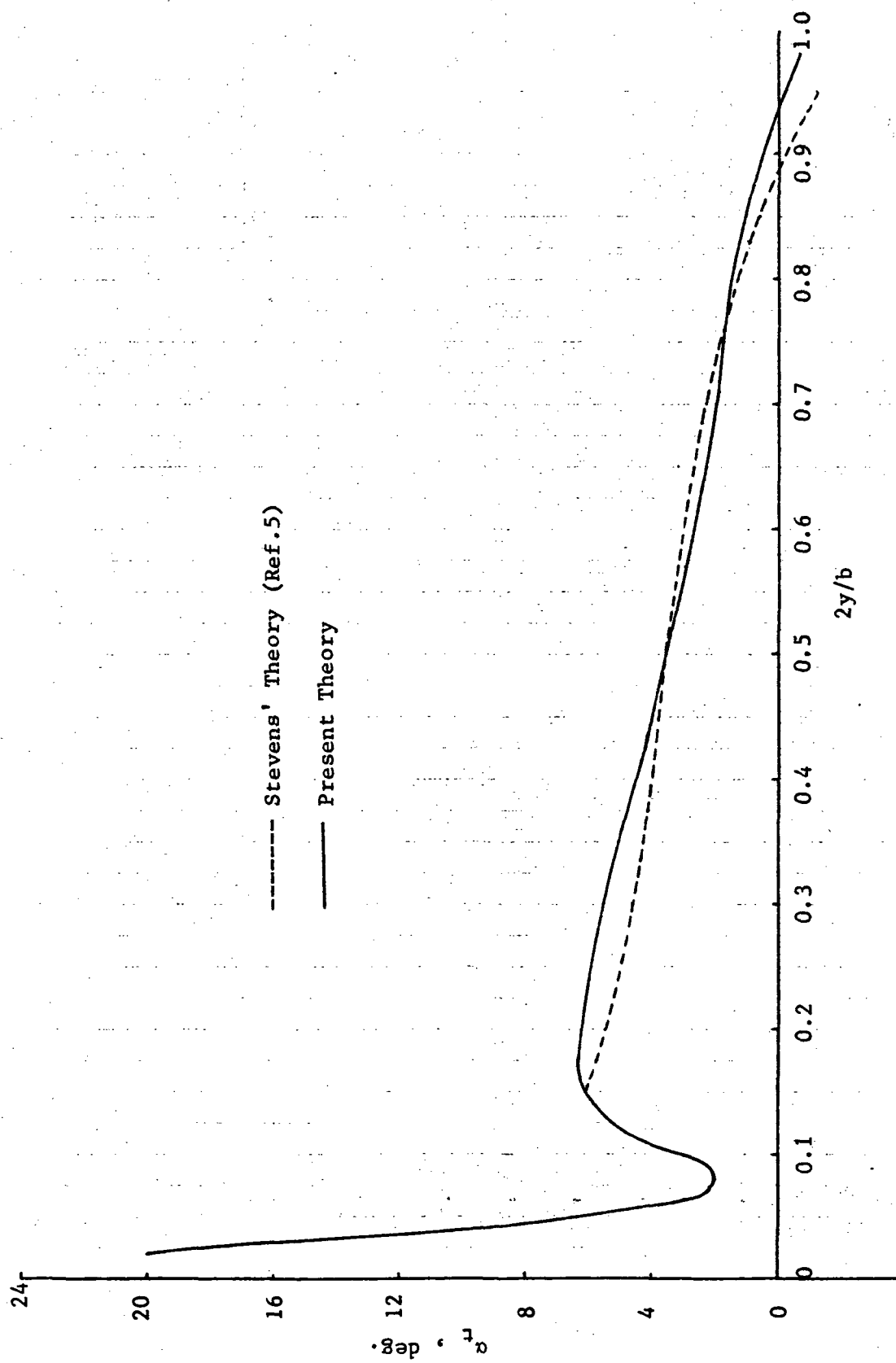


Figure 7. Twist Distribution in the jet-off case. ($AR = 5.5$, $\bar{C}_L = 0.6$, $\bar{C}_m = -0.036$, $\alpha = 0^\circ$)

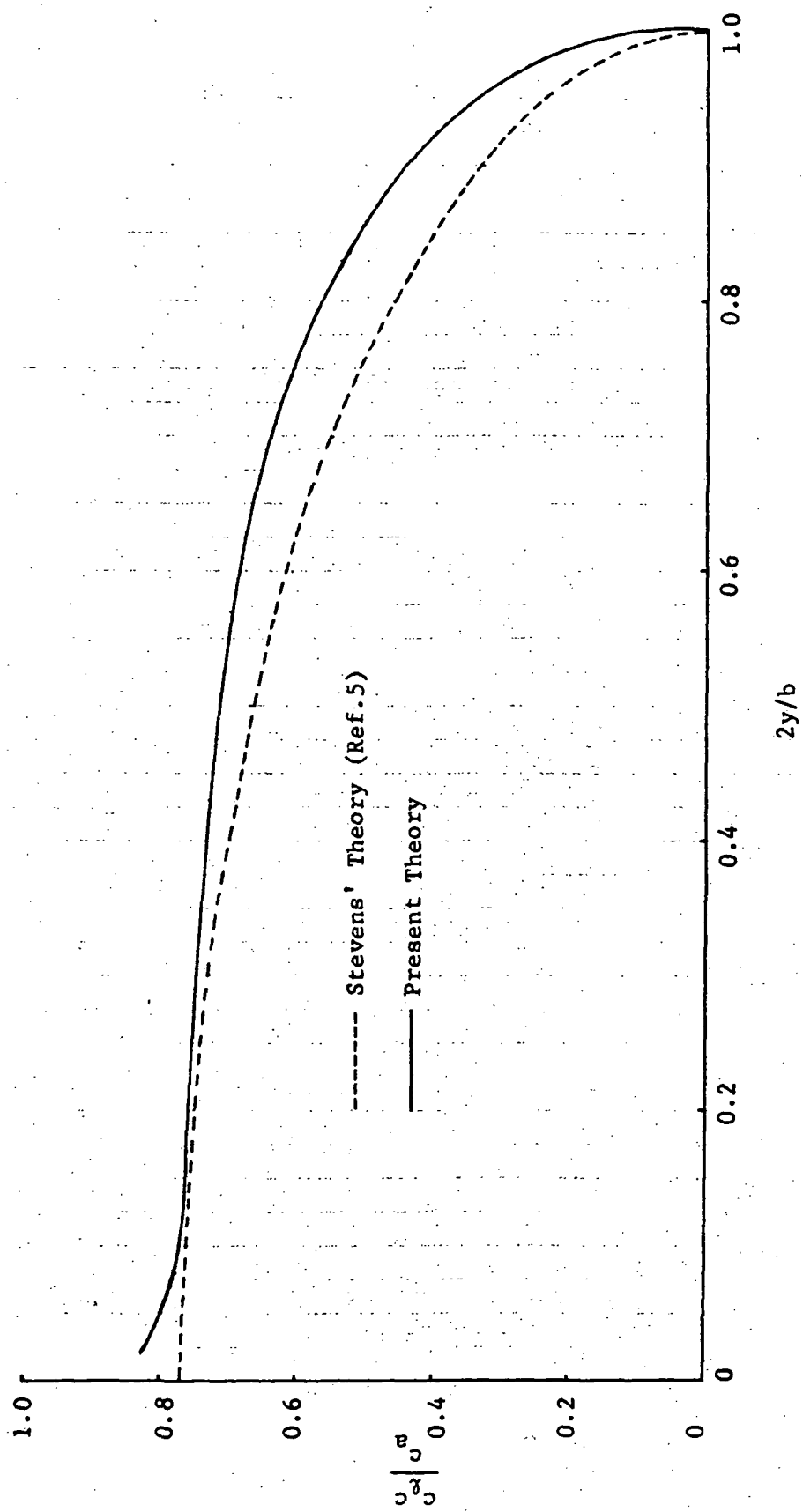


Figure 8. Span Loading in the jet-off case. ($AR = 5.5$, $\bar{C}_L = 0.6$, $\bar{C}_m = -0.036$, $\alpha = 0^\circ$)

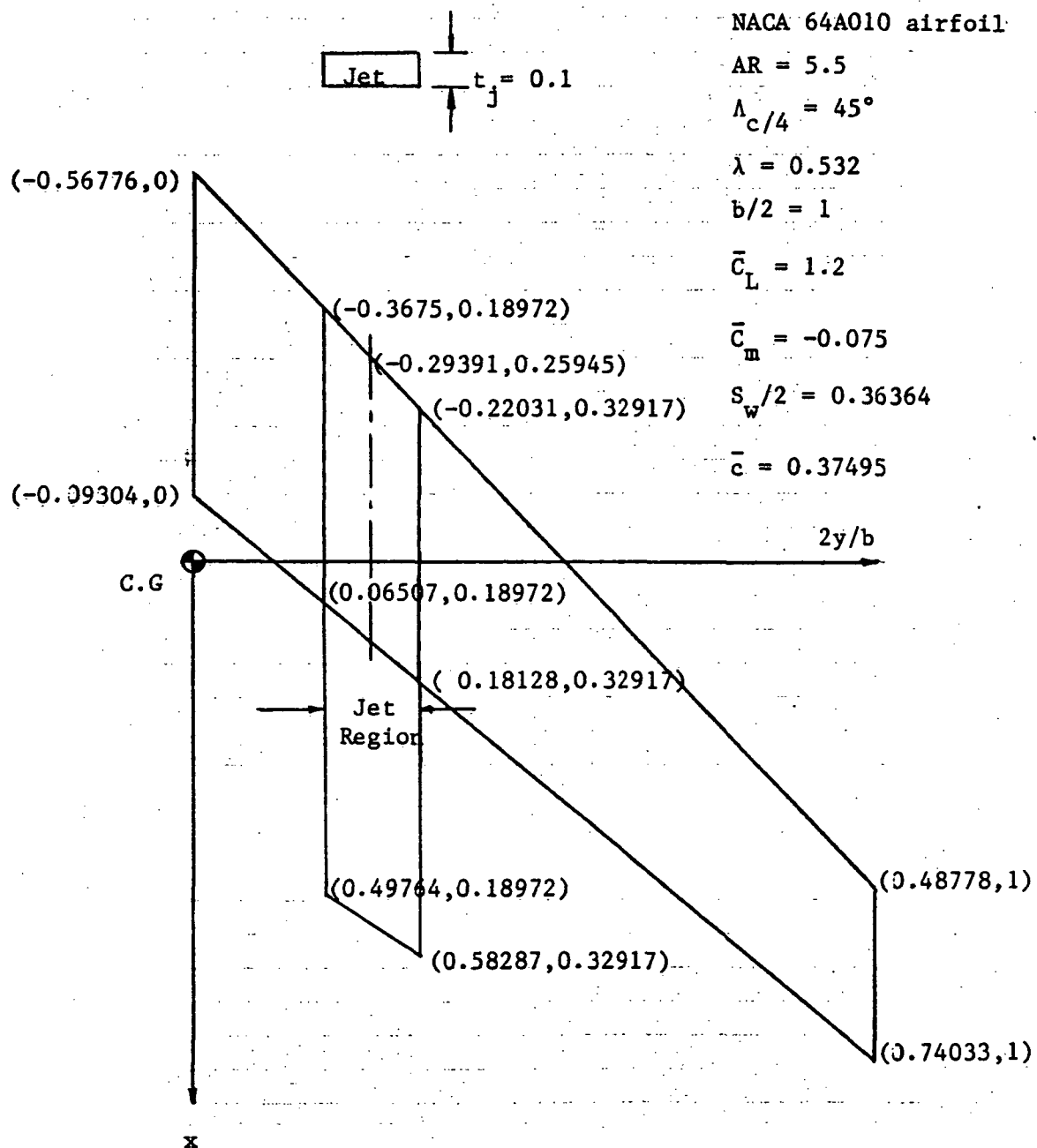


Figure 9. Geometry of Wing Planform and Jet location in the Jet-on case.

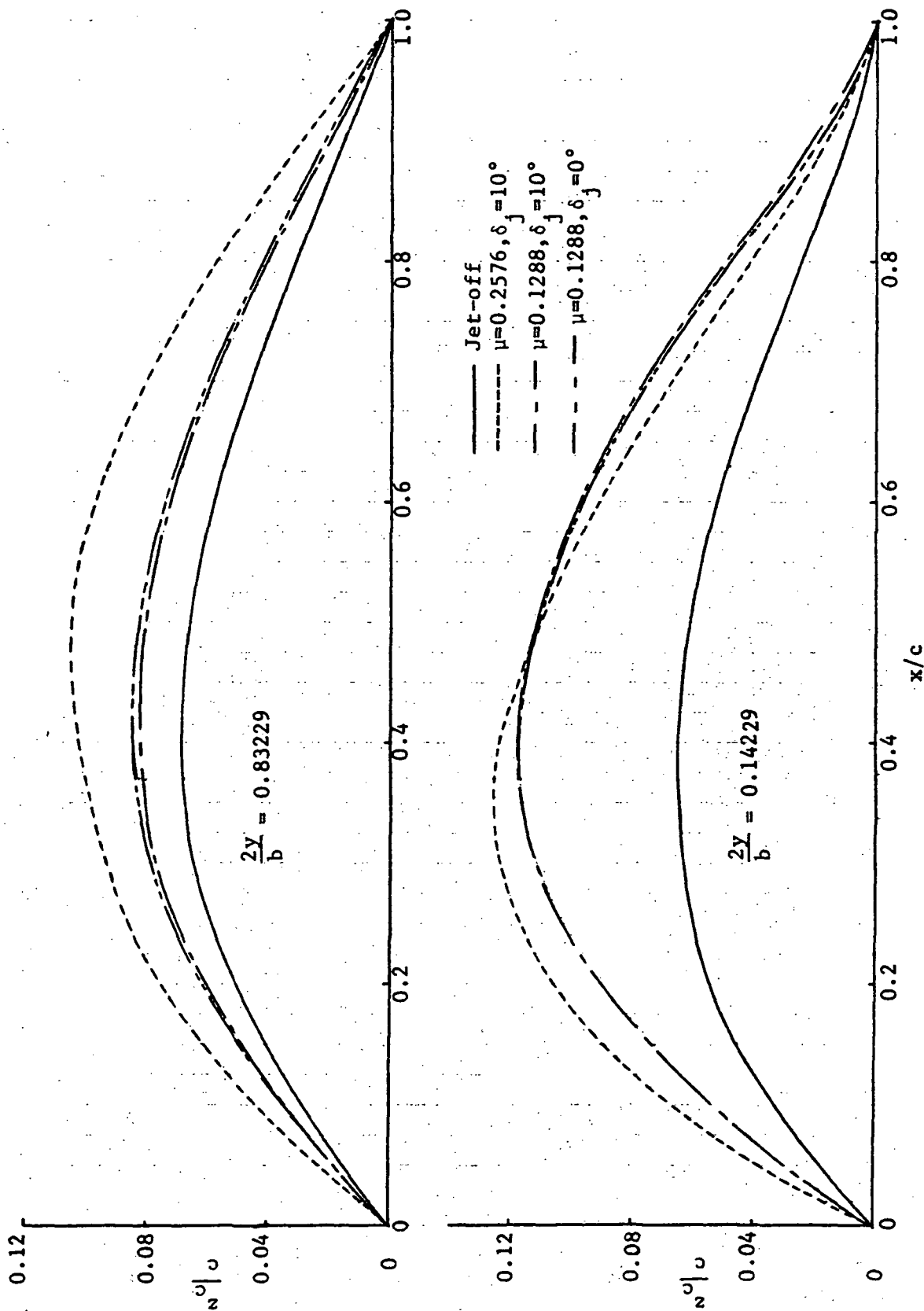


Figure 10. Mean Camber Shape (outside the jet region) in the jet-on case.

($\bar{C}_L=1.2, \bar{C}_m=-0.075, C_\mu=1.676, t_j=0.1, M_o=M_j=0, \alpha=0^\circ$)

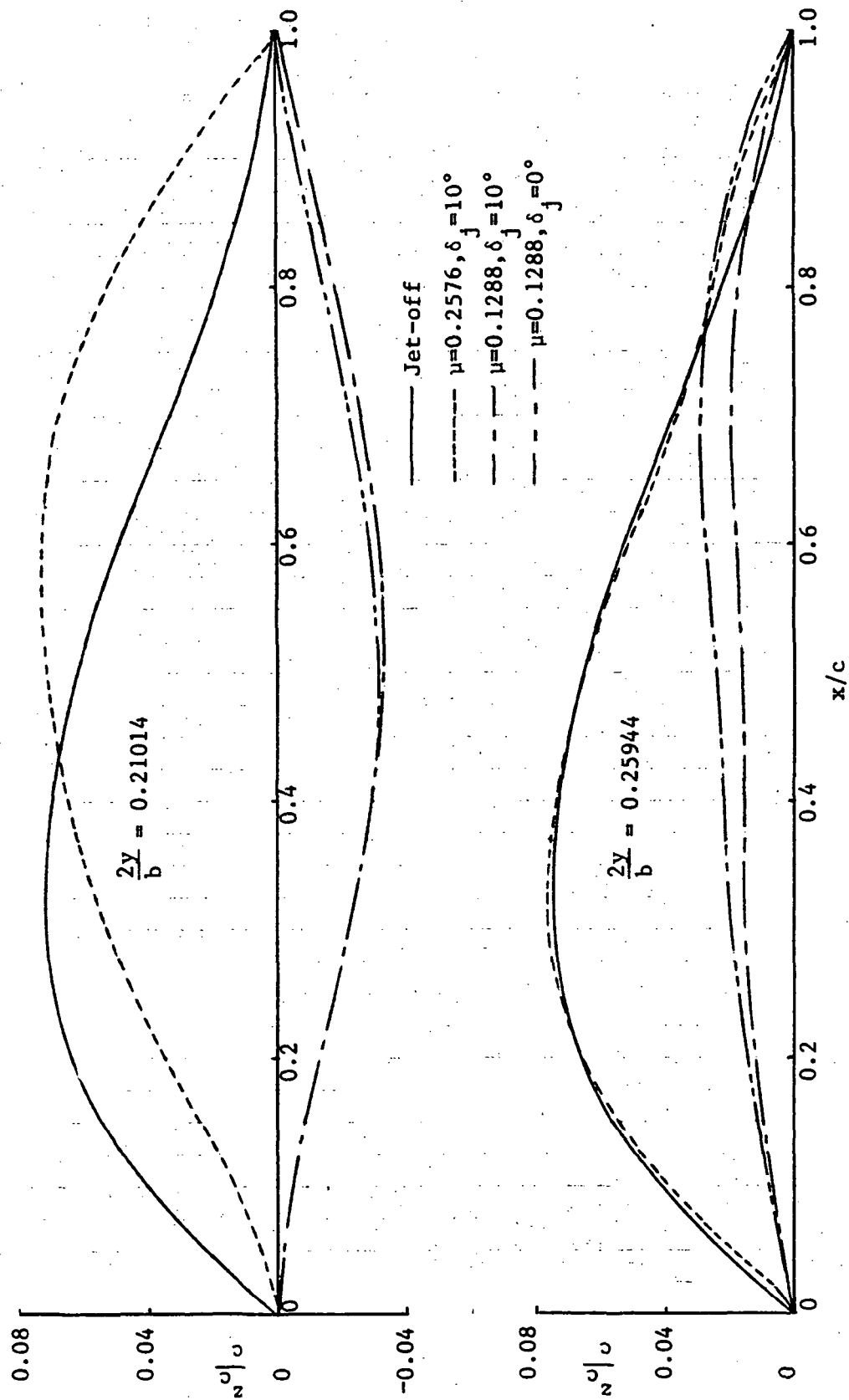


Figure 11. Mean Camber Shape (inside the jet region) in the jet-on case.

$$(\bar{C}_L=1.2, \bar{C}_m=-0.075, C_u=1.676, t_j=0.1, \alpha=0^\circ, M_o=M_j=0)$$

region must be largely reduced from the wing-alone configuration. In the example shown, the camber ordinates become negative in the inboard vortex strip and the flat smooth camber in the outboard vortex strip. When μ is increased to 0.2576 and δ_j is 10° , the aerodynamic jet interaction is either to shift the maximum camber ordinate backward ($y = 0.21014$) or to increase the camber ordinates near the trailing-edge ($y = 0.25944$). Also, in Fig. 11 when δ_j is increased from 0° to 10° , the mean camber is decreased positively, especially, near the trailing-edge. From the results of Figs. 10 - 11, the trend is seen to be that the distribution of the final mean camber shape after the optimization process should be such that the loading are decreased inside the jet region and increased outside the jet region. Figs. 12 - 14 illustrate the pressure distributions at four spanwise stations. In Fig. 12 the μ effect on the pressure distribution outside the jet region are as follows. In the figure, the so-called initial pressure distribution is obtained by applying the jet on the wing-alone optimized configuration. It is seen that at a given μ , the final pressure distributions are increased after the optimization process. Also, the final pressure distributions are increased as μ is increased from 0.1288 to 0.2576. The effect of δ_j is so small that its effect on the difference in pressure distribution is not shown in Fig. 12. Figs. 13 - 14 show the pressure distribution inside the jet region at two spanwise stations. It is seen that there is a high peak in the initial pressure distribution with strong jet strength. After the optimization process, the final pressure distributions become flat. As μ is increased from 0.1288 to 0.2576, it seems that the final pressure loading becomes smoother, and the difference between initial and final pressure distribution is small. At the same μ , when δ_j is increased from 0° to

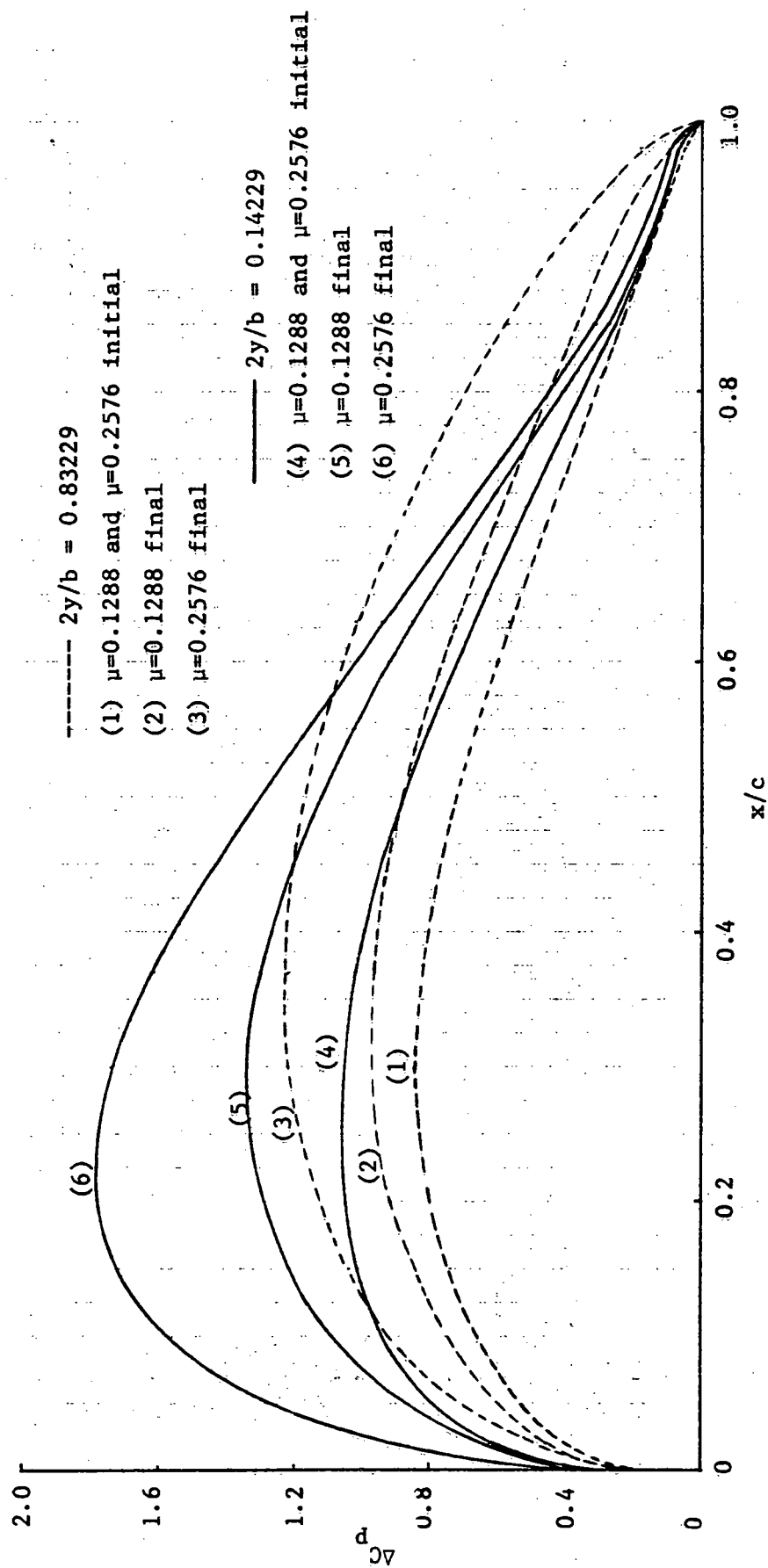


Figure 12. Pressure Distribution (outside the jet region) in the jet-on case.

($\bar{C}_L=1.2, \bar{C}_m=-0.075, C_\mu=1.676, t_j = 0.1, M_0=M_j=0, \alpha=0^\circ$)

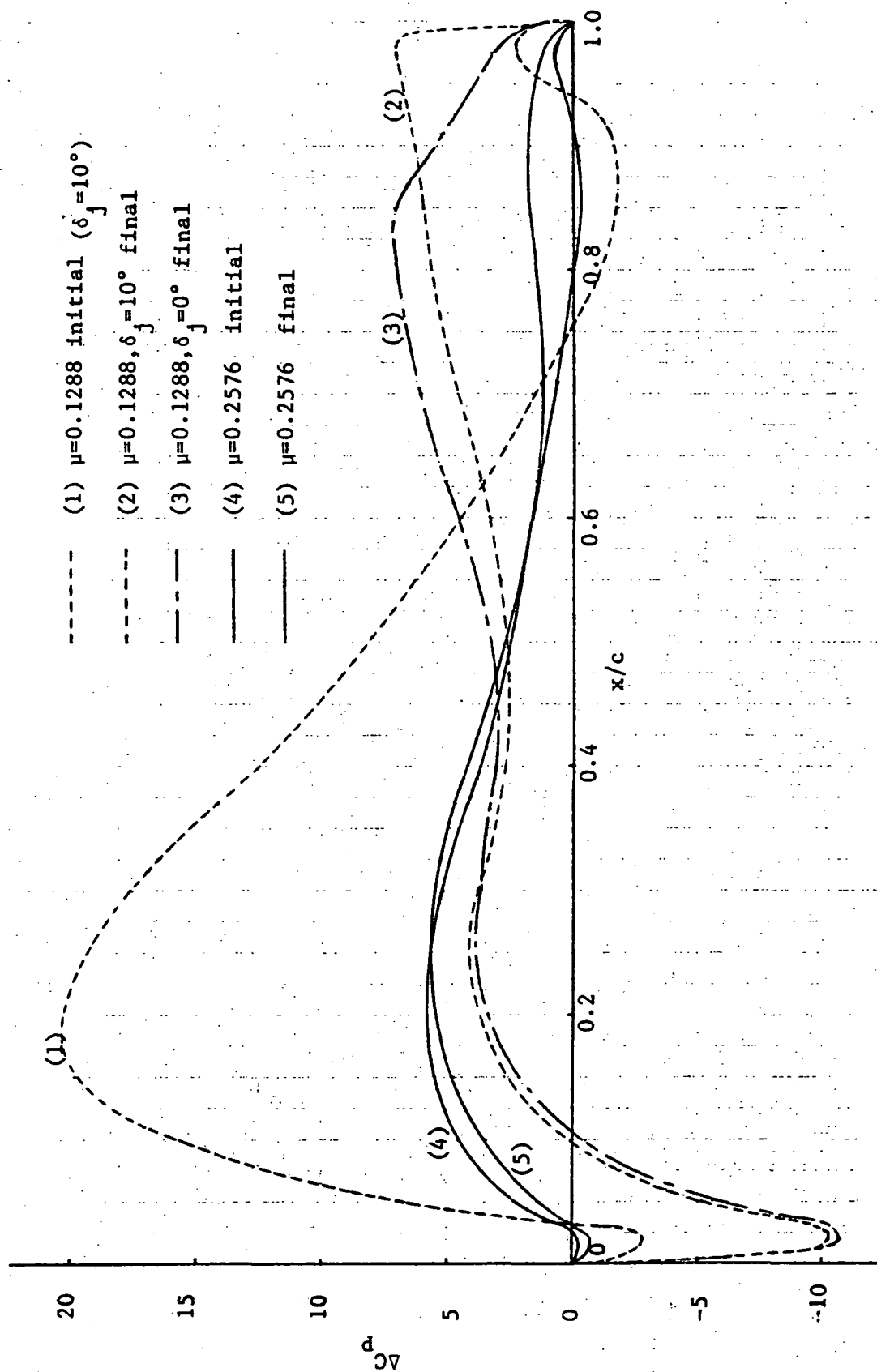


Figure 13. Pressure Distribution (inside the jet region $2y/b=0.25944$) in the jet-on case.

$$(\bar{C}_L=1.2, \bar{C}_m=-0.075, C_\mu=1.676, t_j=0.1, M_o=M_j=0, \alpha=0^\circ)$$

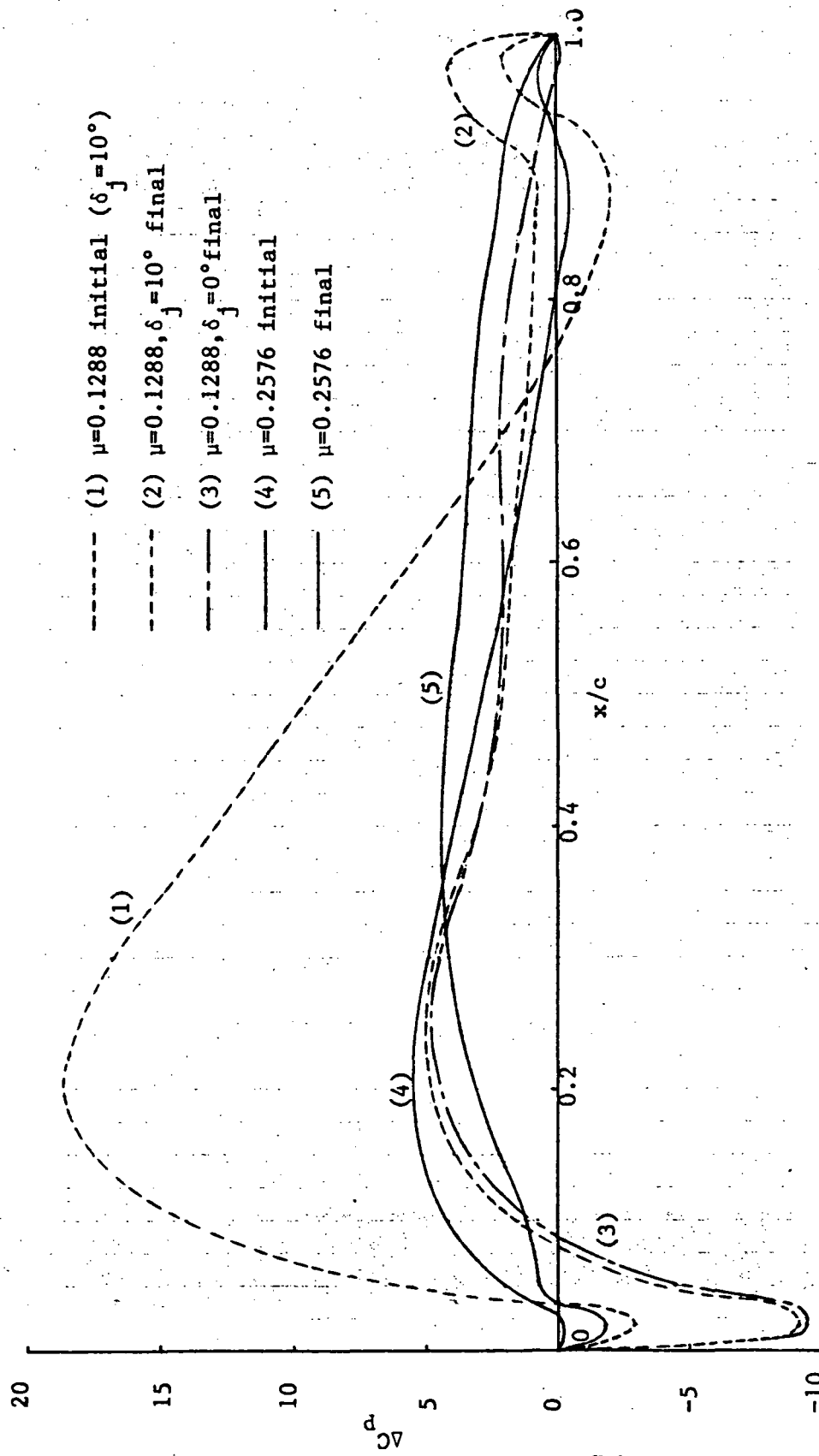


Figure 14. Pressure Distribution (inside the jet region $2y/b=0.21014$) in the jet-on case.
 $(\bar{C}_L=1.2, \bar{C}_m=-0.075, C_\mu=1.676, t_j=0.1, M_o=M_j=0, \alpha=0^\circ)$

10°, the pressure distribution is again changed only slightly. Fig. 15 indicates that the final loading is seen to be still concentrated in the jet region. This is probably because of the jet spreading effect has not been accounted for. From the above results, it is seen that the smaller the μ is, the higher the span loading will be inside the jet region. The initial and final pressure distributions for $\mu = 0.1288$ and $\mu = 0.2576$ are also shown in Fig. 15. The distributions of local angle of attack in the spanwise direction over the semi-span are shown in Fig. 16. It is seen that to reduce the loading inside the jet region negative local angle of attack are needed. As μ is decreased, the local angle of attack is increased negatively inside the jet region. And the decrease of δ_j would increase the local angle of attack inside the jet region. The large variation in the local angle of attack inside and outside the jet region would be smoothed out if the jet spreading effect is accounted for.

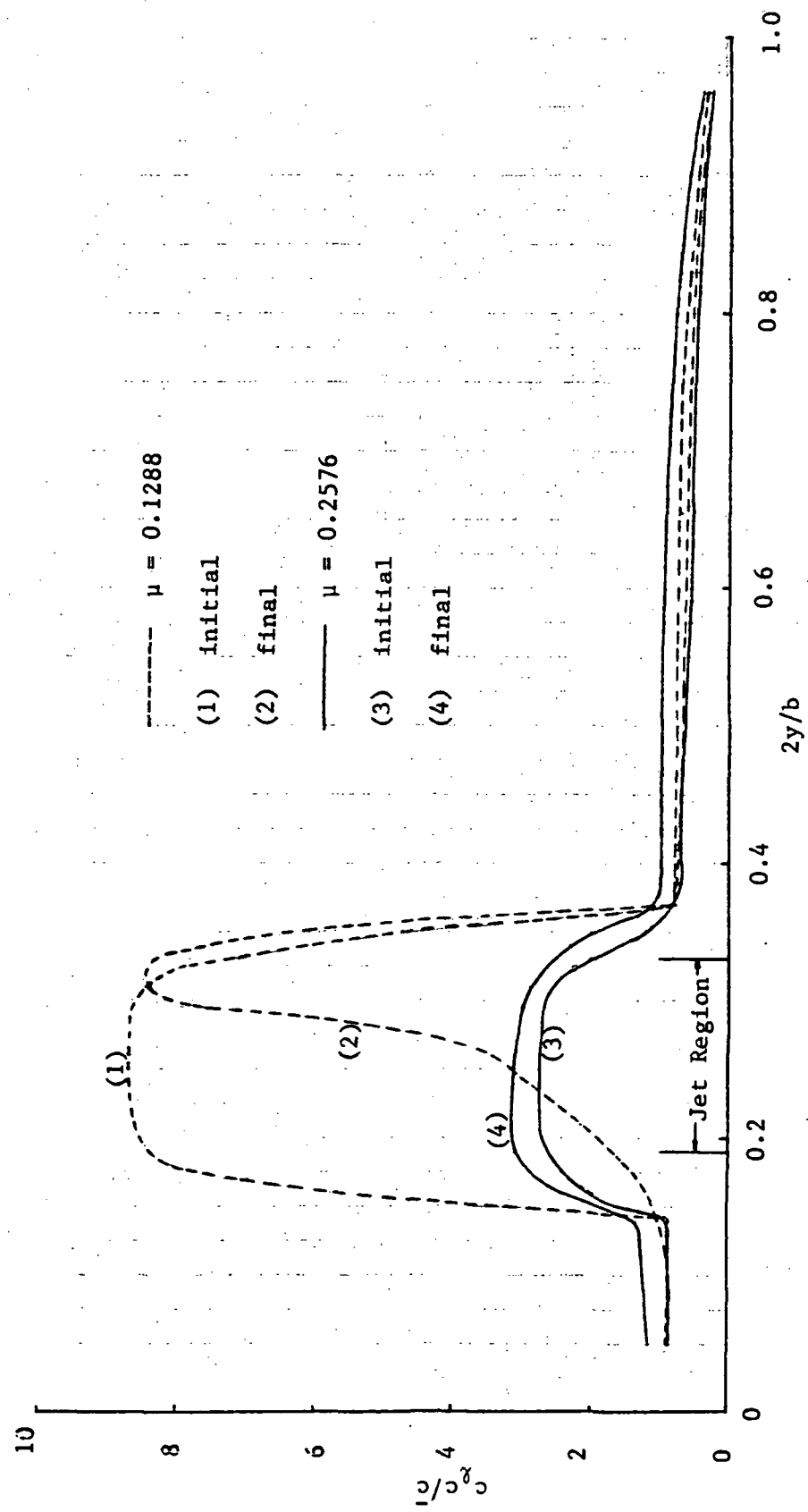


Figure 15. Span Loading in the jet-on case. ($\bar{C}_L = 1.2, \bar{C}_m = -0.075, C_{\mu} = 1.676, t_j = 0.1, M = M_j = 0, \alpha = 0^\circ$)

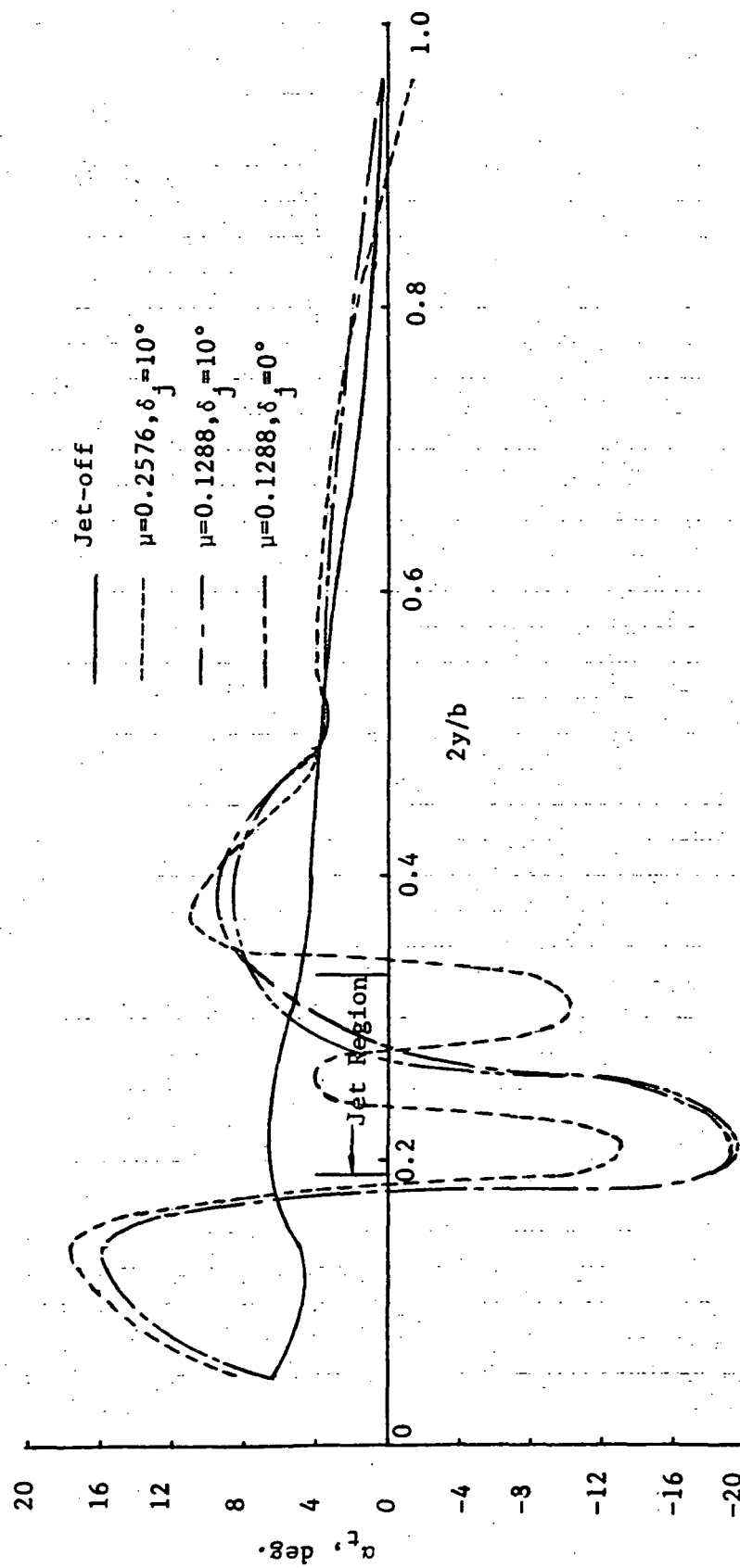


Figure 16. Twist Distribution in the jet-on case.
 $(C_L=1.2, C_m=-0.075, C_\mu=1.676, t_j=0.1 \quad M_\infty=M_j=0, \alpha=0^\circ)$

5. CONCLUSIONS AND RECOMMENDATIONS

By using Lan's QVLM (Ref. 9) and his wing-jet interaction theory (Ref.10 and 11) , an optimization method for calculating the mean camber surface and twist distribution for the minimum induced drag configuration with the upper-surface-blowing jet has been developed. The predicted results show good agreement with Stevens' (Ref.5) theoretical method for configurations without the jet effect. Because of lack of data for comparison, the accuracy of the theory with the blowing jet effect cannot be established. However, the trend of jet effect on camber ordinates, span loading, twist and pressure distribution has been investigated.

The investigation made so far has been for a swept, tapered wing with zero leading-edge suction and the jet exit at the leading-edge in the incompressible flow only. The present method can be extended to handle jet exit away from the leading-edge. Further study for different planforms at some Mach numbers and higher free stream to jet velocity ratio is recommended.

6. REFERENCES

1. Munk, M.M., "The Minimum Induced Drag of Aerofoils", NACA TR 121, 1921.
2. Mangler, W., "The Lift Distribution of Wings with End Plates", NACA TM 856, 1938.
3. Cone, C.D., Jr., "The Theory of Induced Lift and Minimum Induced Drag of Nonplanar Lifting System", NASA TR R-139, 1962.
4. Lundry, J.L. and Lissaman, P.B.S., "A Numerical Solution for the Minimum Induced Drag of Nonplanar Wings", Journal of Aircraft, Vol. 5, No. 1, Jan.-Feb. 1968, pp. 17-21.
5. Stevens, J.R. and McDonald, J.W., "Subsonic Lifting Surface Design and Analysis Procedure", NOR-64-195, 1965, Northrop Corp., Aircraft Div., Hawthorne, Calif.
6. Loth, J.L. and Boyle, R.E., "Optimum Loading on Nonplanar Wings at Minimum Induced Drag", Aerospace Eng. TR-19 (Contract N00014-68-A-1512), West Virginia Univ., Aug. 1969.
7. Lamar, J.E., "A Vortex-Lattice Method for The Mean Camber Shapes of Trimmed Noncoplanar Planforms with Minimum Vortex Drag", NASA TN D-8090, JUNE 1976.
8. Watkins, C.E., Woolston, D.S., and Cunningham, H.J., "A Systematic Kernel Function Procedure for Determining Aerodynamic Forces on Oscillating or Steady Finite Wings at Subsonic Speed", NASA TR R-48, 1958.
9. Lan, C.E., "A Quasi-Vortex-Lattice Method in Thin Wing Theory", Journal of Aircraft, Vol. 11, No. 9, Sept. 1974, pp. 518-527.

10. Lan, C.E., and Campbell, J.F., "Theoretical Aerodynamics of Upper-Surface-Blowing Jet-Wing Interaction", NASA TN D-7936, Nov. 1975.
11. Lan, C.E., and Campbell, J.F., "A Wing-Jet Interaction Theory for USB Configurations", Journal of Aircraft, Vol. 13, No. 9, Sept. 1976, pp. 718-726.
12. Lan, C.E., "A Trigonometric Interpolation Formula", Appendix B of The Induced Drag of Oscillating Airfoils in Linear Subsonic Compressible Flow, KU-FRL-400, June 1975.
13. Kelly, H.J., "Method of Gradients", Ch.6 of Optimization Techniques with Applications to Aerospace Systems, ed. G. Leitmann, Academic Press, New York. 1962
14. Woodward, F.A., Tinoco, E.N., and Larsen, J.W., "Analysis and Design of Supersonic Wing-Body Combinations, Including Flow Properties in the Near Field. Part I - Theory and Application", D6-15044-1, Aug. 1967, The Boeing Company, Commercial Airplane Division, Renton, Washington. pp. 81-86. (NASA CR-73106)
15. Selby, S.M., "Handbook of Tables for Mathematics", 3rd Edition, CRC, 1967.
16. Williams, J., and Ross, A.J., "Some Airframe Aerodynamic Problems at Low Speed", in "International Congress on Subsonic Aeronautics", Annals of the New York Academy of Science, Vol. 154, Art. 2, Nov. 1968.
17. Lan, C.E., Fillman, G.L. and Fox, C.H. Jr., "Computer Program for Calculating Aerodynamic Characteristics of Upper-Surface-Blowing and Over-Surface-Blowing Configurations", NASA TM X-73987, Feb. 1977.

Appendix A

Gradient Projection Method with Linear Constraints (Ref.13)

Consider the objective function $C_{D,i}$ of N variables $\gamma_{w1}, \dots, \gamma_{wn}$, which possesses continuous partial derivatives with respect to these variables. Starting at some point $\gamma_{wk} = \bar{\gamma}_{wk}$, $k=1, \dots, n$, moving with a small distance ds defined in the Euclidean sense:

$$ds^2 = \sum_{k=1}^N (d\gamma_{wk})^2 \quad (A.1)$$

Then,

$$1 - \sum_{k=1}^N \left(\frac{d\gamma_{wk}}{ds} \right)^2 = 0 \quad (A.2)$$

Since the steepest descent direction of $C_{D,i}$ is the direction of the most negative $\frac{dC_{D,i}}{ds}$, thus,

$$\begin{aligned} \frac{dC_{D,i}}{ds} &= \sum_{k=1}^N \frac{\partial C_{D,i}}{\partial \gamma_{wk}} \frac{d\gamma_{wk}}{ds} \\ &= \nabla C_{D,i} \cdot \frac{d\gamma_w}{ds} < 0 \end{aligned} \quad (A.3)$$

The method described below is to find the direction of steepest descent among the directions which make Eq.(A.3) stationary subject to Eq.(A.1).

By using Lagrange multiplier λ_0 , the following functional can be formed:

$$\sum_{k=1}^N \frac{\partial C_{D,i}}{\partial \gamma_{wk}} \frac{d\gamma_{wk}}{ds} + \lambda_0 \left[1 - \sum_{m=1}^N \left(\frac{d\gamma_{wm}}{ds} \right)^2 \right] \quad (A.4)$$

Differentiating Eq.(A.4) with respect to $(\frac{d\gamma_{wk}}{ds})$ and setting the result to zero, it is found that :

$$\frac{\partial C_{D,i}}{\partial \gamma_{wk}} + \lambda_o (-2 \frac{d\gamma_{wk}}{ds}) = 0, \quad k = 1, \dots, N \quad (A.5)$$

or,

$$\frac{d\gamma_{wk}}{ds} = \frac{1}{2\lambda_o} \frac{\partial C_{D,i}}{\partial \gamma_{wk}} \quad (A.6)$$

Substitution of Eq.(A.6) into Eq.(A.2) gives :

$$1 - \sum_{k=1}^N \left(\frac{1}{2\lambda_o} \frac{\partial C_{D,i}}{\partial \gamma_{wk}} \right)^2 = 0 \quad (A.7)$$

from which λ_o can be found :

$$\lambda_o = \pm \frac{1}{2} \left[\sum_{k=1}^N \left(\frac{\partial C_{D,i}}{\partial \gamma_{wk}} \right)^2 \right]^{1/2} \quad (A.8)$$

Provided the partial derivatives $\frac{\partial C_{D,i}}{\partial \gamma_{wk}}$ are not all zero, there are two distinct sets of directional numbers which make $\frac{dC_{D,i}}{ds}$ stationary.

From Eqs.(A.5) and (A.8), it is easily seen that :

$$\frac{d\gamma_{wk}}{ds} = \pm \frac{\partial C_{D,i}}{\partial \gamma_{wk}} \left[\sum_{m=1}^N \left(\frac{\partial C_{D,i}}{\partial \gamma_{wm}} \right)^2 \right]^{-1/2} \quad (A.9)$$

$k = 1, \dots, N$

From Eq.(A.3) the directional derivative can be shown to be :

$$\frac{dC_{D,i}}{ds} = \pm \left[\sum_{m=1}^N \left(\frac{\partial C_{D,i}}{\partial \gamma_{wm}} \right)^2 \right]^{1/2} \quad (A.10)$$

Let σ be a time parameter. Consider the motion along the negative gradient direction as a continuous process. Then Eq.(A.1) becomes :

$$\frac{ds}{d\sigma} = \left[\sum_{m=1}^N \left(\frac{d\gamma_{wm}}{d\sigma} \right)^2 \right]^{1/2} = V \quad (A.11)$$

From Eqs.(A.9) and (A.11), it can be seen that :

$$\frac{d\gamma_{wk}}{d\sigma} = - \left[\sum_{n=1}^N \left(\frac{d\gamma_{wn}}{d\sigma} \right)^2 \right]^{1/2} \left[\sum_{m=1}^N \left(\frac{\partial C_{D,i}}{\partial \gamma_{wm}} \right)^2 \right]^{-1/2} \frac{\partial C_{D,i}}{\partial \gamma_{wk}},$$

$$k = 1, \dots, N \quad (A.12)$$

$$\text{Let } V = K \left[\sum_{m=1}^N \left(\frac{\partial C_{D,i}}{\partial \gamma_{wm}} \right)^2 \right]^{1/2}, \quad K > 0 \quad (A.13)$$

Then,

$$\frac{d\gamma_{wm}}{d\sigma} = - K \frac{\partial C_{D,i}}{\partial \gamma_{wm}}, \quad m=1, \dots, N \quad (A.14)$$

Eq.(A.14) shows that the motion in the negative gradient direction is assured by setting the time derivatives of the coordinates γ_w proportional to the partial derivatives of $C_{D,i}$.

If the stepwise version is considered, then Eq.(A.14) becomes :

$$\gamma_{wm}^{(p+1)} = \gamma_{wm}^{(p)} - K \frac{\partial C_{D,i}}{\partial \gamma_{wm}} \Delta\sigma, \quad m=1, \dots, N \quad (A.15)$$

where the constant K may be absorbed in the step size $\Delta\sigma$. Hence :

$$\gamma_{wm}^{(p+1)} = \gamma_{wm}^{(p)} - \frac{\partial C_{D,i}}{\partial \gamma_{wm}} \Delta\sigma, \quad m = 1, \dots, N \quad (A.16)$$

If the objective function $C_{D,i}$ is subject to the two linear equality constraints,

$$C_L (\gamma_{w1}, \dots, \gamma_{wn}) = \bar{C}_L \quad (A.17)$$

$$C_m (\gamma_{w1}, \dots, \gamma_{wn}) = \bar{C}_m \quad (A.18)$$

the relation appropriate to a stepwise process analogous to that given by Eq. (A.16) are :

$$\gamma_{wk}^{(p+1)} = \gamma_{wk}^{(p)} - \left(\frac{\partial C_{D,i}}{\partial \gamma_{wk}} + \lambda_1 \frac{\partial C_L}{\partial \gamma_{wk}} + \lambda_2 \frac{\partial C_m}{\partial \gamma_{wk}} \right) \Delta \sigma$$

$$k = 1, \dots, N \quad (A.19)$$

or,

$$\Delta \gamma_{wk} + \lambda_1 \frac{\partial C_L}{\partial \gamma_{wk}} \Delta \sigma + \lambda_2 \frac{\partial C_m}{\partial \gamma_{wk}} \Delta \sigma = - \frac{\partial C_{D,i}}{\partial \gamma_{wk}} \Delta \sigma \quad (A.20)$$

By Taylor's series expansion, Eqs. (A.17) and (A.18) become :

$$C_L (\gamma_{w1}, \dots, \gamma_{wn}) = C_L (\bar{\gamma}_{w1}, \dots, \bar{\gamma}_{wn}) +$$

$$\sum_{k=1}^N \frac{\partial C_L}{\partial \gamma_{wk}} (\bar{\gamma}_{w1}, \dots, \bar{\gamma}_{wn}) (\gamma_{wk} - \bar{\gamma}_{wk})$$

$$(A.21)$$

$$C_m (\gamma_{w1}, \dots, \gamma_{wn}) = C_m (\bar{\gamma}_{w1}, \dots, \bar{\gamma}_{wn}) +$$

$$\sum_{k=1}^N \frac{\partial C_m}{\partial \gamma_{wk}} (\bar{\gamma}_{w1}, \dots, \bar{\gamma}_{wn}) (\gamma_{wk} - \bar{\gamma}_{wk})$$

$$(A.22)$$

Assume that the constraints are satisfied at the point $\gamma_{wk} = \bar{\gamma}_{wk}$. Then Eqs.(A.21) and (A.22) become:

$$\sum_{i=1}^N \frac{\partial C_L}{\partial \gamma_{wi}} \Delta \gamma_{wi} = 0 \quad (A.23)$$

$$\sum_{i=1}^N \frac{\partial C_m}{\partial \gamma_{wi}} \Delta \gamma_{wi} = 0 \quad (A.24)$$

In the present method, since the initially computed C_L and C_m values approach the constrained values gradually, Eqs.(A.23) and (A.24) become the following modified form which are actually applied in the iterative process:

$$\sum_{i=1}^N \frac{\partial C_L}{\partial \gamma_{wi}} \Delta \gamma_{wi} = \bar{C}_L - C_L^{(p)} \quad (A.25)$$

$$\sum_{i=1}^N \frac{\partial C_m}{\partial \gamma_{wi}} \Delta \gamma_{wi} = \bar{C}_m - C_m^{(p)} \quad (A.26)$$

where $C_L^{(p)}$ and $C_m^{(p)}$ are the computed values at the p-th iteration.

The optimization equations include Eqs.(A.20), (A.25) and (A.26). They are to restore the linear equality constraints and adjust the variables γ_{wk} . The optimal solution of γ_{wk} can be found as the objective function $C_{D,i}$ reaches the minimum.

Appendix B

Description of the Computer Program

This computer program provides a theoretical method for determining the minimum induced drag configurations in the wing-alone and jet-on (USB) cases. The first part of the program is used to set up the influence coefficient matrices of the boundary conditions (the detailed explanation is in Ref. 17). The calling routines of this part include " GEOMTY ", " JETOFF " and " JETON ". The optimum camber shape and twist distribution for the minimum induced drag can be determined by using the second part of the program. The calling routines of this part include " WALNOL ", " INVMTX ", " COMJET " and " JETNOL ". In the wing-alone case, the optimum solution can be found from the subroutine " WALNOL ". In the jet-on case, the subroutines " INVMTX ", " COMJET " and " JETNOL " should be used. The initial wing-alone vortex strengths used in the jet-on case are obtained by Lagrange interpolation from the optimum results in the wing-alone case.

Pre-Run Check List

Before running the computer program, the following checklist should be completed:

- (1) To use the adjustable dimensions in the program, the three constants of IPANEL, ICW and JPANEE should be declared as input parameters in the following subroutines:

IPANEL and JPANEE ----- Subroutines { " WALNOL "
" INVMTX "

IPANEL, ICW and JPANEE ----- Subroutines { " COMJET "
" JETNOL "

The constants IPANEL, ICW and JPANEE are defined as follows:

IPANEL Total number of wing vortices (LPANEL).

ICW Total number of chordwise vortices along each
vortex strip.

JPANEE Total number of jet vortices in the outer or
inner flow (JPANEL).

- (2) For IPANEL = 60, ICW = 6, JPANEE = 80, the minimum memory needed is 74K (decimal).
- (3) If ITAPE = 0, the subroutines " INVMTX " and " COMJET " are executed and all the matrices are calculated and stored on tape. If ITAPE = 1, the subroutines " INVMTX " and " COMJET " are bypassed and the calculation proceeds using the matrices already computed (and available on tape).

- (4) Nine temporary files and one tape must be provided. The detailed explanation of each file is given below:

- File 01 The influence coefficient matrix $[N_{WW}]$ for the wing-alone case.
- File 02 The tangential velocities on the trailing jet surface to be used to satisfy the jet flap effect.
- File 03 All the influence coefficient matrices of the boundary conditions for the jet-on case.
- File 04 The influence coefficient matrix after being interpolated for the wing-alone case ($[A]$).
- File 08 The coefficient matrix of the optimization equations and the right hand side of those equations.
- File 09 The inverted augmented matrix of the boundary conditions.
- File 10 The derivatives of camber slope with respect to wing-alone vortex strength.
- File 11 The influence coefficient matrices after being interpolated for the jet-on case ($[A], [B]$).
- File 12 The derivatives of the jet vortex strength in the outer flow and of the additional wing vortex strength — both taken with respect to the wing-alone vortex strength.

- (5) Check input data.

Input Data Format

Group 1. Format 13A6 1 card
Any title identifying the case to be run.

Group 2. Format 4(6X,I4) 1 card
ICASE Number of cases to be run.
NG = 0 if all cases have the same geometry other than
 the angle of attack.
 = 1 if new configurations or different freestream-
 jet velocity ratios are to be treated.
ISYM = 0 for a centered jet.
 = 1 , otherwise.
ITAPE = 0 if all matrices are to be calculated and stored
 on tape.
 = 1 if all matrices on tape are to be used.

Group 3. Format 8F10.5 1 card
AM1 Mach number of the freestream.
AM2 Mach number of the jet flow.
VMU Freestream velocity divided by jet velocity.
TEMP Jet static temperature divided by freestream static
 temperature. Assumed to be the same as ratio of
 freestream density and jet density.
ALP Angle of attack in degrees.
XEL X-coordinate of the wing L.E. at the jet centerline.
XET X-coordinate of the wing T.E. at the jet centerline.

Group 4.	Format	2(6X,I4) 5F10.5	1 card
	NFP	Number of flap sections, including the jet span, A maximum of five flap sections may be input.	
	NJP	Numerical order of the jet span among the NFP sections.	
	DF(I) I=1,NFP	Flap deflection angles in degrees for the flap sections.	
Group 5.	Format	8F10.5	1 card
	HALFSW	One half of the reference wing area.	
	TWIST	Difference in angle of attack at the tip and the root in degrees. Negative for washout.	
	TWISTR	Incidence angle of the root chord in degrees.	
	XJ	X,Y, and Z-coordinates of the midpoint of the jet cross section at the exit.	
	YJ		
	ZJ		
	RJ	Jet radius.	
	CREF	Reference chord length.	
Group 6.	Format	3F10.5	1 card
	TEANGL	Trailing-edge half angle of the airfoil at the jet centerline in degrees. For USB applications, it may be arbitrary.	
	PTIAL	= 0. for clean or full-span flap configuration. = 1. for partial-span flap deflection.	
	USB	= 0. for OWB applications. = 1. for USB applications.	

Group 7. Format 3F10.5 1 card

CMU Jet thrust coefficient.

DFJ Jet deflection angle in degrees at the trailing edge relative to the chord line. At small flap angles, it may be taken as the sum of flap angle and the airfoil trailing edge half angle. At large flap angles, experimental values should be used.

TNJ = 0. if the entrainment is not to be accounted for. Usually this is the case if the jet is on the wing surface.
 = 1. if the entrainment due to an equivalent round jet is to be accounted for when a rectangular jet is not on the wing surface.

Group 8. Format 8(6X,I4) 1 card

NC Number of spanwise sections. A natural way of dividing a planform into sections is to follow lines of discontinuity, such as edges of partial-span flap, jet boundary, wing edge discontinuities, etc.

M1(I) Number of vortex strips in each spanwise section,
 I=1,NC plus one.

Group 9. Format 5(6X,I4) 1 card

 NJW(I) The numerical order of the flap and jet spans
 I=1,NFP among the spanwise sections.

Group 10. Format 3(6X,I4) 1 card

 NW(I) Number of chordwise vortex elements in each
 I=1,2,3 chordwise section. The planform is divided into
 chordwise sections according to such lines of
 discontinuity as jet exit, flap hinge, etc.

Group 11. Format 6F10.5 1 card

 XXL(1) x-coordinate of the leading edge of the inboard
 boundary chord of a given spanwise section.

 XXT(1) x-coordinate of the trailing edge of the inboard
 boundary chord of the same spanwise section.

 YL(1) y-coordinate of the inboard boundary chord.

 XXL(2) x-coordinate of the leading edge of the outboard
 boundary chord of the same spanwise section.

 XXT(2) x-coordinate of the trailing edge of the outboard
 boundary chord.

 YL(2) y-coordinate of the outboard boundary chord.

Group 12. Format 6(6X,I4) 1 card

 NNJ Number of jet sections.

 NSJ = Number of jet circumferential strips minus one
 for a noncentered jet (always use odd numbers).
 = Number of jet circumferential strips on the half
 jet plus one for centered jet (always use even
 numbers).

NCJ(I) Number of streamwise vortex elements in each section. For those jet sections above the wing, these numbers should agree with the corresponding numbers of wing vortices.

Group 13. Format 4F10.5 (4 x NNJ) cards

XXL(I)	}	Coordinates of the bounding lines defining the rectangular jet sections in USB applications. They are the x-coordinates of the leading and trailing edges, the y-coordinate and the z-coordinate of the bounding line. There are 4 cards for each jet section. The jet section behind the trailing edge should be at least one local chord in length.
XXT(I)		
YL(I)		
ZL(I)		

I=1,...,4

Group 14. Format (4F10.5,I10) 1 card

CDBAR	Theoretical minimum induced drag coefficient in the wing alone case.
CLBAR	Lift constraint in the wing alone case.
CMBAR	Pitching moment constraint in the wing alone case.
DELTA	Initial step size in the wing alone case.
MAXP	Maximum number of iterations in the wing alone case.

Sample Input Data for the Wing-alone and Jet-on cases

Card

```

1      * * * WING ALONE CASE * * *
2      1      1      1      1
3      0.      0.      0.2576      1.      0.      -0.29391      0.12318
4      1      1      0.
5      0.36364      0.      0.      -0.29391      0.25945      0.05      1.      0.37495
6      0.      1.      1.
7      1.676      10.      0.
8      1      11
9      1
10     6      0      0
11     -0.56776      -0.09304      0.      0.48778      0.74033      1.
12     1      7      6
13     -0.56776      -0.09304      0.      0.
14     -0.56776      -0.09304      0.      0.1
15     0.48778      0.74033      1.      0.1
16     0.48778      0.74033      1.      0.
17     0.02084      0.6      -0.036      50.      15
18     * * * JET ON CASE WITH UPPER SURFACE BLOWING * * *
19     0.      0.      0.2576      1.      0.      -0.29391      0.12318
20     1      1      0.
21     0.36364      0.      0.      -0.29391      0.25945      0.05      1.      0.37495
22     0.      1.      1.
23     1.676      10.      0.
24     3      3      4      6
25     2
26     6      0      0
27     -0.56776      -0.09304      0.      -0.3675      0.06507      0.18972
28     -0.3675      0.06507      0.18972      -0.22031      0.18128      0.32917
29     -0.22031      0.18128      0.32917      0.48778      0.74033      1.
30     2      7      6      4
31     -0.3675      0.06507      0.18972      0.
32     -0.3675      0.06507      0.18972      0.1
33     0.22031      0.18128      0.32917      0.1
34     0.22031      0.18128      0.32917      0.
35     0.06507      0.49764      0.18972      0.
36     0.06507      0.49764      0.18972      0.1
37     0.18128      0.58287      0.32917      0.1
38     0.18128      0.58287      0.32917      0.
39     1.2      -0.075      0.1      20
40     5      0.4

```

Output Data Format

The title of the job and the input data will be printed in the same format as it was input. For the upper-surface-blowing configuration, the following output data will be printed :

HALFSW	The reference half-wing area.
CREF	The reference chord length.
LPANEL	Total number of wing vortices.
JPANEL	Total number of jet vortices in the outer or inner flow.
LAST	The number of wing vortices plus the number of outer jet vortices. $LAST = LPANEL + JPANEL$
LTOTAL	The total number of vortices which is the sum of wing vortices, outer jet vortices and inner jet vortices. $LTOTAL = LAST + JPANEL$ $= LPANEL + 2 (JPANEL)$

Vortex Element Endpoint Coordinates

X_1, Y_1, Z_1	Coordinates for the inboard endpoint of a bound vortex element.
X_2, Y_2, Z_2	Coordinates for the outboard endpoint (corresponding to (X_1, Y_1, Z_1)) of a bound vortex element.

Note: Wing elements are listed first and then jet elements. The number of elements listed should equal (LAST).

Control Point Coordinates

XCP Two columns of control point coordinates, one point
YCP for each vortex element.
ZCP

Note: Control points on the wing are listed first and then control points on the jet surface. The number of points listed should equal (LAST).

Overall Aerodynamic Coefficients

DELTA The step size which is used in the N-th iteration.
CDII The computed induced drag coefficient in the N-iteration.
CLII The computed lift coefficient in the N-th iteration.
CMII The computed pitching moment coefficient in the N-th iteration.

Camber Shape and Twist Distribution

ALPAO Local angle of attack (twist) along each vortex strip.
CAMZC Camber ordinates along each vortex strip.

Sectional Pressure and Force Data

- XV Fraction of local chord.
- YV Spanwise fraction of semispan.
- CP The total ΔC_p at the given (XV,YV) point due to both wing and jet induced circulation.
- CPW The ΔC_p that would occur at that same point for the wing alone case.
- Y/SP The y-coordinate of the chord divided by the half span.
- CL The sectional lift coefficient due to circulation (jet on), nondimensionalized with $q_\infty c$.
- CM The sectional pitching moment coefficient about the Y-axis, nondimensionalized with $q_\infty c^2$.
- CT The sectional leading edge thrust coefficient, nondimensionalized with $q_\infty c$.
- CDI The sectional induced drag coefficient, nondimensionalized with $q_\infty c$.
- CLW The sectional lift coefficient for the wing alone case.
- CMW The sectional pitching moment coefficient (about Y-axis) for the wing alone case.
- CDW The sectional induced drag coefficient for the wing alone case.

Span Loading Computation

Jet-Off Span Loading

$$= \frac{(CLW \times CH)}{C_{REF}} \quad (\text{where } CH \text{ is local chord length})$$

Jet-On Span Loading

$$= \frac{(CL \times CH)}{C_{REF}} \quad (\text{where } CH \text{ is local chord length})$$

Total Force and Moment Data

The Lift Coefficient

The total circulation lift coefficient due to the wing, wing-jet interaction and entrainment (if any).

Total Induced Drag Coefficient

Total induced drag coefficient for the jet on case.

Induced Drag Parameter

$$= \frac{C_{D,i}}{C_L^2} \quad \text{or} \quad \frac{1}{\pi e AR}$$

Total Pitching Moment Coefficient

Pitching moment coefficient due to all circulation forces, about the Y-axis. Nondimensionalized with CREF.

Coanda Effect

Coanda Lift Coefficient

The lift coefficient due to the lift component of the jet reaction force.

Coanda Drag Coefficient

The drag coefficient due to the drag component of the jet reaction force.

Coanda Moment Coefficient

Pitching moment coefficient due to the pitching moment caused by the jet reaction force (about Y-axis).

The last four coefficients printed are due to aerodynamic forces and moments generated solely by the wing without any jet effect (jet off).

Appendix C

Computer Program Listing

(This program is operational on Honeywell 66/60 computer)

Main Program	I	Subroutine " WALNOL "
	I	
Subroutine " STREAM "	I	Subroutine " WALNO2 "
	I	
Subroutine " SPEED "	I	Subroutine " WALNO3 "
	I	
Subroutine " NORSPD "	I	Subroutine " WALNO4 "
	I	
Subroutine " VMSEQN "	I	Subroutine " WALNO5 "
	I	
Subroutine " INTEG "	I	-----
	I	
Subroutine " INVRCX "	I	Subroutine " INVMTX "
	I	
-----	I	Subroutine " JETNO3 "
	I	
Subroutine " GEOMTY "	I	-----
	I	
Subroutine " RESHAP "	I	Subroutine " COMJET "
	I	
Subroutine " PANEL "	I	Subroutine " JETNO4 "
	I	
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	I	
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	I	
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	I	
Subroutine " JSHAPE "	I	Subroutine " JETNOL "
	I	
-----	I	Subroutine " JETNO7 "
	I	
	I	Subroutine " JETNO8 "
	I	
Subroutine " JETOFF "	I	Subroutine " JETNO9 "
	I	
Subroutine " JETON "	I	Subroutine " CAMBER "
	I	
Subroutine " MATRIX "	I	Subroutine " LOAD "
	I	
Subroutine " SKIP "	I	
	I	
Subroutine " WING "	I	
	I	
	I	

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$      OPTION  FORTRAN
$      FORTY
$      INCODE  IBMF
C      MINIMUM INDUCED DRAG CONFIGURATION WITH JET INTERACTION
C      BY C. EDWARD LAN AND JENN-LOUH PAO OF THE UNIVERSITY OF KANSAS
C      THIS PROGRAM IS DESIGNED TO FIND THE OPTIMUM CAMBER SHAPE, TWIST
C      DISTRIBUTION, SPAN LOADING, AND CHORDWISE PRESSURE DISTRIBUTION
C      CORRESPONDING TO THE MINIMUM INDUCED DRAG CONFIGURATION IN THE
C      WING ALONE AND JET ON ( UPPER-SURFACE-BLOWING ) CASES.
C
      DIMENSION AW(300),TITLE(13)
      COMMON /SCHEME/ C(2),X(10,41),Y(10,41),SLOPE(15),XL(2,15),XTT(41),
1XLL(41)
      COMMON /GEOM/ HALFSW,XCP(200),YCP(200),ZCP(200),XLE(50),YLE(50),XT
1E(50),PSI(20),CH(95),XV(200),YV(100),SN( 8,8),XN(200,2),YN(200,2),
2ZN(200,2),WIDTH(8),YCON(25),SWEEP(50),HALFB,SJ(21,8),EX(95,2),TX(
395,2),SC(160,5),SI(160,5),LC(3)
      COMMON /AERO/ AM1,AM2,B1,B2,CL(30),CT(30),CD(30),GAM(2,100)
      COMMON /COST/ LTOTAL,LPAN1,NJW(5),LPANEL,IENTN,LPAN2,EXIT,PTIAL,TW
1IST,DF(5),NFP
      COMMON /CONST/ NCS,NCW,M1(8),NSJ,NCJ(5),LAST,MJW1(3,5),MJW2(3,5),J
1PANEL,MJJ(5),NW(3),NNJ,NJP
      COMMON /PARAM/ ALPT,ALFC,ALPS,CDF,SDF,TH,TDF
      COMMON /JET/ PK1,XC,XJT(31),A(31),B(31)
      COMMON /ADD/ CP(100),CM(30),BREAK(8),SWP(8,15),GAL(30),ISYM,VMU,VU
1,TEMP,FCR,CAMLER,CAMLET,CAMTER,CAMTET,XJ,YJ,ZJ,RJ,ALP,CREF,TWISTR
      COMMON /CLOPE/ DZDXK(100),ALPA0(15),GCB(100),GCBX(100),THETAK(10)
1,CCX(100),OZDXK(100),GAN(2,100)
      COMMON /LING/ GLBAR,GMBAR,FCLII,FCMII
      COMMON /WLONE/ DZDXKW(100),GAMW(100),CAMZCW(100),ALPAOW(20)
      COMMON /IDENT/ DZDXK1(100),GAM1(100),CAMZC1(100),ALPAO1(20),YLE1(2
10)
2  FORMAT (5F10.5)
3  FORMAT (7(6X,I4))
19  FORMAT (13A6)
406  FORMAT (40H*****
      PI=3.14159265
      READ (5,19) (TITLE(I),I=1,13)
      WRITE (6,406)
      WRITE (6,19) (TITLE(I),I=1,13)
      WRITE (6,406)
      NCON=1
C
C ***NUMBER OF CASES TO BE RUN, GEOMETRY CODE (=1 IF GEOMETRY VARIES.
C   IN THIS CASE, ALPHA MAY ALSO BE DIFFERENT. =0 FOR THE SAME GEOME-
C   TRY BUT DIFFERENT ALPHA'S), AND SYMMETRY CODE (=0 FOR A CENTERED
C   JET, AND=1 OTHERWISE), ITAPE=1 FOR MATRICES ON TAPE ARE TO BE USED
C   ITAPE=0, THEN COMPUTE ALL MATRICES ***
C
      READ (5,3) ICASE,NG,ISYM,ITAPE
      WRITE (6,3) ICASE,NG,ISYM,ITAPE

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20 CONTINUE
    CALL LLINK(6HLINK11)
    CALL GEOMTY(KCODE)
    CALL LLINK(6HLINK22)
    CALL JETOFF
    CALL LLINK(6HLINK33)
    CALL WALNOL
98 CONTINUE
    READ (5,19) (TITLE(I),I=1,13)
    WRITE (6,406)
    WRITE (6,19) (TITLE(I),I=1,13)
    WRITE (6,406)
        CALL LLINK(6HLINK11)
    CALL GEOMTY(KCODE)
    L1=LPANEL+1
    J7=LPANEL+JPANEL
    IF (ITAPE .EQ. 1) GO TO 40
        CALL LLINK(6HLINK22)
    CALL JETOFF
    CALL JETON(KCODE)
        CALL LLINK(6HLINK44)
    CALL INVMTX
        CALL LLINK(6HLINK55)
    CALL COMJET (KCODE)
10 CONTINUE
    REWIND 01
    REWIND 03
    REWIND 04
    REWIND 09
    REWIND 10
    REWIND 11
    REWIND 12
    REWIND 13
    DO 41 I=1,LPANEL
        READ (01) (AW(J),J=1,L1)
41 WRITE (13) (AW(J),J=1,L1)
    DO 42 I=1,LTOTAL
        READ (03) (AW(J),J=1,LTOTAL)
42 WRITE (13) (AW(J),J=1,LTOTAL)
    DO 44 I=1,LTOTAL
        READ (09) (AW(J),J=1,LTOTAL)
44 WRITE (13) (AW(J),J=1,LTOTAL)
    DO 45 I=1,LPANEL
        READ (10) (AW(J),J=1,LPANEL)
45 WRITE (13) (AW(J),J=1,LPANEL)
    DO 46 I=1,LPANEL
        READ (11) (AW(J),J=1,J7)
46 WRITE (13) (AW(J),J=1,J7)
    DO 47 I=1,LPANEL
        READ (12) (AW(J),J=1,J7)
47 WRITE (13) (AW(J),J=1,J7)

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GO TO 100
40 REWIND (13)
REWIND 01
REWIND 03
REWIND 04
REWIND 09
REWIND 10
REWIND 11
REWIND 12
DO 51 I=1,LPANEL
READ (13) (AW(J),J=1,L1)
51 WRITE (01) (AW(J),J=1,L1)
DO 52 I=1,LTOTAL
READ (13) (AW(J),J=1,LTOTAL)
52 WRITE (03) (AW(J),J=1,LTOTAL)
DO 54 I=1,LTOTAL
READ (13) (AW(J),J=1,LTOTAL)
54 WRITE (09) (AW(J),J=1,LTOTAL)
DO 55 I=1,LPANEL
READ (13) (AW(J),J=1,LPANEL)
55 WRITE (10) (AW(J),J=1,LPANEL)
DO 56 I=1,LPANEL
READ (13) (AW(J),J=1,J7)
56 WRITE (11) (AW(J),J=1,J7)
DO 57 I=1,LPANEL
READ (13) (AW(J),J=1,J7)
57 WRITE (12) (AW(J),J=1,J7)
100 CONTINUE
REWIND 04
REWIND 11
DO 25 I=1,LPANEL
READ (11) (AW(K),K=1,J7)
WRITE (04) (AW(K),K=JPANEL+1,J7)
25 CONTINUE
CALL LLINK(6HLINK66)
CALL JETNOL(KCODE)
NCON=NCON+1
IF (NCON .LE. ICASE) GO TO 98
IF (NCON .GT. ICASE) GO TO 5
IF (NG .EQ. 1) GO TO 2C
5 CONTINUE
STOP
END
$ FORTY
$ LIMITS ,27K
$ INCODE IBMF
SUBROUTINE STREAM(ALPHA,VMU,I,IPHI,LPANEL,TEMP,LPAN1,LPAN2,ISYM,
1KCODE,EXIT,MJ,INDEX,BA)
C TO COMPUTE THE RIGHT HAND SIDE OF THE SIMULTANEOUS EQUATIONS
DIMENSION PHIN(300),BA(1)
COMMON /AERO/ AM1,AM2,B1,B2,CL(30),CT(30),CD(30),GAM(2,100)

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COMMON /CONST/ NCS,NCW,M1(8),NSJ,NCJ(5),LAST,MJW1(3,5),MJW2(3,5),J
1 PANEL,MJJ(5),NW(3),NNJ,NJP
COMMON /PARAM/ ALPT,ALPC,ALPS,CDF,SDF,TH,TDF
COMMON /GEOM/ HALFSW,XCP(200),YCP(200),ZCP(200),XLE(50),YLE(50),XT
1 E(50),PSI(20),CH(95),XV(200),YV(100),SN( 8,8),XN(200,2),YN(200,2),
2 ZN(200,2),WIDTH(8),YCCN(25),SWEEP(50),HALFB,SJ(21,8),EX(95,2),TX(
3 95,2),SC(160,5),SI(160,5),LC(3)
COMMON /SCHEME/ C(2),X(10,41),Y(10,41),SLOPE(15),XL(2,15),XTT(41),
1 XLL(41)
EQUIVALENCE (X(1,1),PHIN(1))
PI=3.14159265
IUSB=YCON(24)
ZJET=YCON(25)
N1=NNJ-1
N2=NNJ-2
N3=NNJ-3
IF (NNJ.EQ.1) N1=1
NJH=(NSJ+1)/2+1
IF (ISYM .EQ. 0) NJH=NSJ/2
NP=NJH-1
IF (ISYM .EQ. 0) NP=NJH
ALPHA=0.
IF (I .GT. LPANEL) GO TO 1
GO TO 5
1 IF (I .GT. LAST) GO TO 10
IF (EXIT .LE. 0.001) GO TO 2
IF (NNJ .EQ. 1) GO TO 2
IF (I .LE. MJJ(1) .AND. I .NE. MJ) GO TO 5
2 CCNTINUE
ALPHA=ALPT*Y(3,IPHI)*(1.-VMU)
IF (TH .LE. 0.001) GO TO 3
IF (IPHI .EQ. NJH) GO TO 3
IF (ISYM .NE. 0 .AND. IPHI .EQ. 1) GO TO 3
IF (NNJ.EQ.1 .AND. I.GT.LPANEL) ALPHA=ALPHA+CDF*(1.-VMU)
IF (NNJ.NE.1 .AND. I.GT.MJJ(N1)) ALPHA=ALPHA+CDF*(1.-VMU)
3 CONTINUE
IF (ABS(B1-B2) .LE. 0.001) GO TO 28
CALL NORSPD (I,ALPH,LPANEL,IPHI,LPAN1,LPAN2,INDEX,BA)
ALPHA=ALPHA+ALPH
28 IF (KCODE .EQ. 0) GO TO 5
IF (EXIT .LE. 0.001) GO TO 29
IF (NNJ.EQ.1) GO TO 29
IF (I .LE. MJJ(1) .AND. I .EQ. MJ) ALPHA=ALPHA/2.
29 IF (IPHI .EQ. NJH) GO TO 5
IF (ISYM .NE. 0 .AND. IPHI .EQ. 1) GO TO 5
IF (IUSB .EQ. 1 .AND. ZJET .GT. 0.01) GO TO 5
IF (CDF .LT. 0.0001) GO TO 5
IF (NNJ .EQ. 1) GO TO 12
IF (I .LE. MJJ(N1)) GO TO 5
12 IF (IPHI .LT. NJH) IL=IPHI+ISYM
IF (IPHI .GT. NJH) IL=IPHI-NJH+ISYM

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IF (NNJ.EQ.1) MJN1=LPANEL
IF (NNJ.NE.1) MJN1=MJJ(N1)
MF=I-MJN1-(IPHI-1)*NCJ(NNJ)
FNNJ=NCJ(NNJ)
DISTJ=SDF
DLX=DISTJ*.5*PI/FNNJ
SZX=-(1.-VMU)
IQ=(IL-1)*NCJ(NNJ)
IF (NNJ.EQ.1) IP=LPANEL+IQ+1
IF (NNJ.NE.1) IP=MJJ(N1)+IQ+1
DO 6 JJ=1,MF
IF (JJ.EQ.MF) GO TO 7
DXTH=DLX*PSI(JJ)*TEMP*VMU*VMU/TH
GO TO 8
7 DXTH=DLX*PSI(JJ)*TEMP*.5*VMU*VMU/TH
8 JK1=IP+JJ
JK2=JK1-1
PROD=SZX*DXTH
JK3=JK2+NP*NCJ(NNJ)
ALPHA=ALPHA+PROD*(PHIN(JK2)-PHIN(JK3))
6 CONTINUE
GO TO 5
10 CONTINUE
IF (INDEX.EQ.1) GO TO 62
GO TO 63
62 DO 64 M=1,LPANEL
BA(M)=0.0
64 CONTINUE
63 CONTINUE
IJ=I-JPANEL
IF (KCODE.EQ.0) GO TO 30
IF (EXIT.LE.0.01) GO TO 4
IF (NNJ.EQ.1) GO TO 4
IF (IJ.GT.LPANEL.AND.IJ.LE.MJJ(1)) GO TO 5
4 CONTINUE
IF (IUSB.EQ.1.AND.ZJET.GT.0.01) GO TO 30
IF (NNJ.EQ.1) GO TO 30
IF (IJ.GT.MJJ(N1)) GO TO 30
IF (IPHI.LE.NJH) GO TO 30
L1=NJH
IF (ISYM.EQ.0) L1=NJH+1
IF (NW(2).EQ.0) GO TO 70
IF (NW(3).EQ.0) GO TO 71
IF (IJ.GT.MJJ(N2)) GO TO 32
IF (IJ.GT.MJJ(N3)) GO TO 34
IF (NNJ.EQ.4) GO TO 33
IF (NNJ.EQ.5.AND.IJ.GT.MJJ(NNJ-4)) GO TO 33
GO TO 30
71 IF (IJ.GT.MJJ(N2)) GO TO 34
IF (NNJ.EQ.3) GO TO 33
IF (NNJ.EQ.4.AND.IJ.GT.MJJ(N3)) GO TO 33

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GO TO 30
70 IF ( NNJ .EQ. 2) GO TO 33
   IF (NNJ .EQ. 3 .AND. IJ .GT. MJJ(N2)) GO TO 33
   GO TO 30
33 K1=MJW1(1,NJP)+(IPHI-L1-ISYM)*NW(1)-1
   K2=LC(1)+IPHI-L1-ISYM
   KNW=NW(1)
   GO TO 35
34 K1=MJW1(2,NJP)+(IPHI-L1-ISYM)*NW(2)-1
   K2=LC(2)+IPHI-L1-ISYM
   KNW=NW(2)
   GO TO 35
32 K1=MJW1(3,NJP)+(IPHI-L1-ISYM)*NW(3)-1
   K2=LC(3)+IPHI-L1-ISYM
   KNW=NW(3)
35 CONTINUE
   ALPHA1=0.
   ALPHA2=0.
   DO 40 KK=1,KNW
     KL=K1+KK
     AA=1.
     DO 42 L=1,KNW
       LL=K1+L
       IF (L .EQ. KK) GO TO 42
       AA=AA*(XCP(IJ)-XV(LL))/(XV(KL)-XV(LL))
42 CONTINUE
   IF (INDEX.EQ.1) GO TO 65
   ALPHA1=ALPHA1+AA*GAM(1,KL)
   IF (ABS(B1-B2) .LE. 0.001) GO TO 40
   ALPHA2=ALPHA2+AA*GAM(2,KL)
   GO TO 40
65 BA(KL)=AA*(1.-TEMP*VMU*VMU)*0.5
40 CONTINUE
   IF (ABS(B1-B2) .LE. 0.001) ALPHA2=ALPHA1
   ALPHA=(ALPHA2-TEMP*VMU*VMU*ALPHA1)*0.5
   GO TO 5
30 CONTINUE
   CALL SPEED (VMU,I,ALPHA,LPANEL,TEMP,LPAN1,LPAN2,PHIS,IPHI,ISYM,
1 INDEX,BA)
   IF (KCODE .EQ. 0) GO TO 5
   IF (CDF .LT. 0.0001) GO TO 5
   IF (NNJ .EQ. 1) GO TO 39
   IF (IJ .LE. MJJ(N1)) GO TO 5
39 PHIN(IJ)=PHIS
5 CONTINUE
50 FORMAT (6(6X,I4))
   RETURN
   END
$- FORTY
$  LIMITS ,27K
$  INCODE IBMF

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SUBROUTINE SPEED(VMU,I,ALPHA,LPANEL,TEMP,LPAN1,LPAN2,PHIS,IPHI,
1 ISYM,INDEX,BA)

C TO COMPUTE THE INDUCED TANGENTIAL VELOCITIES DUE TO WING ALONE
C VORTICES

DIMENSION SU(100),BA(1)

COMMON /AERO/ AM1,AM2,E1,B2,CL(30),CT(30),CD(30),GAM(2,100)

COMMON /CONST/ NCS,NCW,M1(8),NSJ,NCJ(5),LAST,MJW1(3,5),MJW2(3,5),J

-1 PANEL,MJJ(5),NW(3),NNJ,NJP

COMMON /GEOM/ HALFSW,XCP(200),YCP(200),ZCP(200),XLE(50),YLE(50),XT
1E(50),PSI(20),CH(95),XV(200),YV(100),SN(8,8),XN(200,2),YN(200,2),
2 ZN(200,2),WIDTH(8),YCON(25),SWEEP(50),HALFB,SJ(21,8),EX(95,2),TX(
395,2),SC(160,5),SI(160,5),LC(3)

COMMON /SCHEME/ C(2),X(10,41),Y(10,41),SLOPE(15),XL(2,15),XTT(41),
1XLL(41)

N1=NNJ-1

N2=NNJ-2

N3=NNJ-3

ZJET=YCON(25)

II=I-JPANEL

BE=B1

IC=1

10 CONTINUE

IZ=1

MM=0

ISN=1

NL=NW(1)

NP=NW(1)

B=0.

DO 1 J=1,LPANEL

IF (INDEX.EQ.1) BA(J)=C.0

JJ=J-MM

FN=NL

IF(J .GT. LPAN1 .AND. J .LE. LPAN2) ISN=2

IF (J .GT. LPAN2 .AND. J .LE. LPANEL) ISN=3

IF (J .GE. LPAN1 .AND. J .LT. LPANEL) GO TO 20

GO TO 21

20 NL=NW(2)

IF (J .GE. LPAN2 .AND. J .LT. LPANEL) NL=NW(3)

21 CONTINUE

X1=XN(J,1)-XCP(II)

X2=XN(J,2)-XCP(II)

X12=XN(J,2)-XN(J,1)

Y12=YN(J,2)-YN(J,1)

Z1=-ZCP(II)

Z2=-ZCP(II)

Z12=0.

XZJ=-Z1*X12

DO 2 K=1,2

IF (K .EQ. 1) GO TO 3

N=1

GO TO 4


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3 N=2
4 CONTINUE
YC=(-1.)*N*YCP(II)
Y1=YN(J,1)-YC
Y2=YN(J,2)-YC
XYK=X1*Y12-Y1*X12
YZI=-Z1*Y12
ALB1=XYK*XYK+XZJ*XZJ+BB*YZI*YZI
R1B1=SQRT(X1*X1+BB*Y1*Y1+BB*Z1*Z1)
R2B1=SQRT(X2*X2+BB*Y2*Y2+BB*Z2*Z2)
UUB1=(X2*X12+BB*Y2*Y12+BB*Z2*Z12)/R2B1-(X1*X12+BB*Y1*Y12+BB*Z1*Z12
1)/R1B1
F1=UUB1*YZI/ALB1
SUM=F1*CH(IZ)*SN(JJ,ISN)*GAM(IC,J)/FN
IF (K .EQ. 1) SU(J)=F1*CH(IZ)*SN(JJ,ISN)/FN
IF (INDEX.EQ.1) GO TO 54
GO TO 56
54 BA(J)=BA(J)+F1*CH(IZ)*SN(JJ,ISN)/FN
GO TO 2
56 B=B+SUM
2 CONTINUE
IF (J .LT. NM) GO TO 1
IZ=IZ+1
MM=NM
NM=NM+NL
1 CONTINUE
NJH=(NSJ+1)/2+1
IF (ISYM .EQ. 0) NJH=NSJ/2
IF (IPHI .EQ. NJH) GO TO 30
IF (ISYM .NE. C .AND. IPHI .EQ. 1) GO TO 30
IF (NNJ .EQ. 1) GO TO 30
IF (II .GT. MJJ(N1)) GO TO 30
IF (IPHI .GT. NJH .AND. ZJET .LE. 0.01) GO TO 30
IF (IPHI .GT. NJH) L1=NJH
IF (ISYM .EQ. 0 .AND. IPHI .GT. NJH) L1=NJH+1
IF (IPHI .LE. NJH) L1=1
NZ=1
IF (NW(2) .NE. 0 .AND. NW(3) .EQ. 0) NZ=2
IF (NW(3) .NE. 0) NZ=3
IF (NNJ .LE. 3 .AND. NW(2) .NE. 0) IR=N2
IF (NNJ .LE. 3 .AND. NW(2) .EQ. 0) IR=N1
IF (NNJ .GE. 4 .AND. NW(3) .NE. 0) IR=N3
IF (NNJ .EQ. 4 .AND. NW(3) .EQ. 0) IR=N2
DO 41 MP=1,NZ
K1=MJW1(MP,NJP)+(IPHI-L1-ISYM)*NW(MP)-1
K2=LC(MP)+IPHI-L1-ISYM
KNW=NW(MP)
35 CONTINUE
K1=K1-KNW
K2=K2-1
MR=3

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      IF (K1 .GE. 0) GO TO 40
      K1=K1+KNW
      K2=K2+1
      MR=2
40   DO 42 NR=1,MR
      SUM=0.
      DO 36 KK=1,KNW
      KL=K1+KK
36   SUM=SUM+SU(KL)
      CALL INTEG (RES,KNW,K1,K2,II,BB,IR)
      CORN=0.
      DO 37 KK=1,KNW
      KL=K1+KK
      AA=1.
      DO 38 L=1,KNW
      LL=K1+L
      IF (L .EQ. KK) GO TO 38
      AA=AA*(XCP(II)-XV(LL))/(XV(KL)-XV(LL))
38   CONTINUE
      IF (INDEX.EQ.1) GO TO 58
      GO TO 59
58   BA(KL)=BA(KL)-AA*SUM+AA*RES*8.
      GO TO 37
59   CORN=CORN+AA*GAM(IC,KL)
37   CONTINUE
      B=B-CORN*SUM+CORN*RES*8.
      K1=K1+KNW
      K2=K2+1
42   CONTINUE
      IR=IR+1
41   CONTINUE
30   CONTINUE
      IF (INDEX .EQ. 1) GO TO 65
      GO TO 68
65   CONTINUE
      DO 60 M=1,LPANEL
      BA(M)=BA(M)*(1.-TEMP*VMU*VMU)/8.
60   CONTINUE
68   CONTINUE
      IF (IC .EQ. 2) GO TO 8
      ALPHA1=B/8.
      IC=IC+1
      BB=B2
      IF (ABS(B1-B2) .LE. 0.001) GO TO 7
      GO TO 10
8   ALPHA2=B/8.
      GO TO 6
7   ALPHA2=ALPHA1
6   ALPHA=ALPHA2-TEMP*VMU*VMU*ALPHA1
      PHIS=ALPHA2
100  FORMAT (6(F11.5))

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110 FORMAT (6(5X,15))

RETURN

END

\$ FORTY

\$ INCODE IBMF

SUBROUTINE NORSPD (I,ALPH,LPANEL,IPHI,LPAN1,LPAN2,INDEX,BA)

C TO COMPUTE THE INDUCED NORMAL VELOCITIES DUE TO WING ALONE

C VORTICES

DIMENSION BA(1)

COMMON /AERO/ AM1,AM2,B1,B2,CL(30),CT(30),CD(30),GAM(2,100)

COMMON /CONST/ NCS,NCW,M1(8),NSJ,NCJ(5),LAST,MJW1(3,5),MJW2(3,5),J

1 PANEL,MJJ(5),NW(3),NNJ,NJP

COMMON /GEOM/ HALFSW,XCP(200),YCP(200),ZCP(200),XLE(50),YLE(50),XT

1E(50),PSI(20),CH(95),XV(200),YV(100),SN(8,8),XN(200,2),YN(200,2),

2 ZN(200,2),WIDTH(8),YCCN(25),SWEEP(50),HALFB,SJ(21,8),EX(95,2),TX(

395,2),SC(160,5),SI(160,5),LC(3)

COMMON /SCHEME/ C(2),X(10,41),Y(10,41),SLOPE(15),XL(2,15),XTT(41),

1XLL(41)

NJH=(NSJ-1)/2

IZ=1

MM=0

NM=NW(1)

ISN=1

NL=NW(1)

A1=0.

A2=0.

DO 1 J=1,LPANEL

IF (INDEX.EQ.1) BA(J)=C.

JJ=J-MM

FN=NL

IF (J .GT. LPAN1 .AND. J .LE. LPAN2) ISN=2

IF (J .GT. LPAN2 .AND. J .LE. LPANEL) ISN=3

IF (J .GE. LPAN1 .AND. J .LT. LPANEL) GO TO 10

GO TO 11

10 NL=NW(2)

IF (J .GE. LPAN2 .AND. J .LT. LPANEL) NL=NW(3)

11 CONTINUE

X1=XN(J,1)-XCP(I)

X2=XN(J,2)-XCP(I)

X12=XN(J,2)-XN(J,1)

Y12=YN(J,2)-YN(J,1)

Z12=0.

Z18=ZCP(I)

Z2=-ZCP(I)

XZJ=X1*Z12-Z1*X12

DO 2 K=1,2

IF (K .EQ. 1) GO TO 3

N=1

GO TO 4

3 N=2

4 CONTINUE

```

YC=(-1.)*N*YCP(I)
Y1=YN(J,1)-YC
Y2=YN(J,2)-YC
XYK=X1*Y12-Y1*X12
YZI=Y1*Z12-Z1*Y12
ALB1=XYK*XYK+XZJ*XZJ+B1*YZI*YZI
R1B1=SQRT(X1*X1+B1*Y1*Y1+B1*Z1*Z1)
R2B1=SQRT(X2*X2+B1*Y2*Y2+B1*Z2*Z2)
UUB1=(X2*X12+B1*Y2*Y12+B1*Z2*Z12)/R2B1-(X1*X12+B1*Y1*Y12+B1*Z1*Z12
1)/R1B1
G1=(1.-X1/R1B1)/(Y1*Y1+Z1*Z1)
G2=(1.-X2/R2B1)/(Y2*Y2+Z2*Z2)
ALB2=XYK*XYK+XZJ*XZJ+B2*YZI*YZI
R1B2=SQRT(X1*X1+B2*Y1*Y1+B2*Z1*Z1)
R2B2=SQRT(X2*X2+B2*Y2*Y2+B2*Z2*Z2)
UUB2=(X2*X12+B2*Y2*Y12+B2*Z2*Z12)/R2B2-(X1*X12+B2*Y1*Y12+B2*Z1*Z12
1)/R1B2
G3=(1.-X1/R1B2)/(Y1*Y1+Z1*Z1)
G4=(1.-X2/R2B2)/(Y2*Y2+Z2*Z2)
F13=UUB1*XZJ/ALB1
F12=UUB1*XYK/ALB1
G13=Z2*G2-Z1*G1
G12=-Y2*G2+Y1*G1
F23=UUB2*XZJ/ALB2
F22=UUB2*XYK/ALB2
G23=Z2*G4-Z1*G3
G22=-Y2*G4+Y1*G3
F1=-F13*Y(4,IPHI)*(-1.)*N+F12*Y(3,IPHI)
F2=G13*Y(4,IPHI)*(-1.)*N+G12*Y(3,IPHI)
F3=-F23*Y(4,IPHI)*(-1.)*N+F22*Y(3,IPHI)
F4=G23*Y(4,IPHI)*(-1.)*N+G22*Y(3,IPHI)
7 CONTINUE
IF (INDEX.EQ.1) GO TO 8
A1=A1+(F1+F2)*CH(IZ)*SN(JJ,ISN)*GAM(1,J)/FN
A2=A2+(F3+F4)*CH(IZ)*SN(JJ,ISN)*GAM(2,J)/FN
GO TO 2
8 BA(J)=BA(J)+(F1+F2-F3-F4)*CH(IZ)*SN(JJ,ISN)/(FN*8.)
2 CONTINUE
IF (J.LT. NM) GO TO 1
IZ=IZ+1
MM=NM
NM=NM+NL
1 CONTINUE
ALPH=(A1-A2)/8.
RETURN
END
$ FORTY
$ INCODE IBMF
SUBROUTINE VMSEQN (NC1,K,AA,A,CA)
DIMENSION AA(1),CA(1),A(1)
NC=K*NC1

```

```

SUM1=0.
K1=K-1
JJ=1
DO 3 J=1,K1
SUM1=SUM1+AA(J)*A(JJ)
3 JJ=JJ+NC1+1
SUM1=SUM1+AA(K)
DO 5 I=1,NC1
SUM2=0.
JJ=I+1
DO 4 J=1,K1
SUM2=SUM2+AA(J)*A(JJ)
4 JJ=JJ+NC1+1
KK=K+I
SUM2=SUM2+AA(KK)
5 CA(I)=-SUM2/SUM1
M=1
L=0
KNC=(K-1)*NC1
DO 8 I=1,NC
IF (I.GT.KNC) GO TO 7
MM=(M-1)*NC1+1
IF (I.EQ.MM) GO TO 9
6 KK=KK+1
IL=I+L
A(I)=CA(KK)*BASE+A(IL)
GO TO 8
7 II=I-KNC
A(I)=CA(II)
8 CONTINUE
GO TO 10
9 II=MM+M-1
BASE=A(II)
KK=0
L=L+1
M=M+1
GO TO 6
10 CONTINUE
RETURN
END
$ FORTY
$ INCODE IBMF
SUBROUTINE INTEG (F,NN,LJ,IZ,IJ,B,IR)
COMMON /GEOM/ HALFSW,XCP(200),YCP(200),ZCP(200),XLE(50),YLE(50),XT
1E(50),PSI(20),CH(95),XV(200),YV(100),SN( 8,8),XN(200,2),YN(200,2),
= 2 ZN(200,2),WIDTH(8),YCON(25),SWEEP(50),HALFB,SJ(21,8),EX(95,2),TX(
395,2),SC(160,5),SI(160,5),LC(3)
PI=3.14159265
J=LJ+1
JJ=NN*16
IF (NN .GT. 6) JJ=NN*8

```

```

FJ=JJ
C1=TX(IZ,1)-EX(IZ,1)
C2=TX(IZ,2)-EX(IZ,2)
SUM=0.
DO 1 K=1, JJ
XX1=EX(IZ,1)+C1*SC(K,IR)
XX2=EX(IZ,2)+C2*SC(K,IR)
X1=XX1-XCP(IJ)
X2=XX2-XCP(IJ)
Y1=YN(J,1)-YCP(IJ)
Y2=YN(J,2)-YCP(IJ)
Z1=ZN(J,1)-ZCP(IJ)
Z2=ZN(J,2)-ZCP(IJ)
X12=XX2-XX1
Y12=YN(J,2)-YN(J,1)
Z12=ZN(J,2)-ZN(J,1)
YZI=Y1*Z12-Z1*Y12
XYK=X1*Y12-Y1*X12
XZJ=X1*Z12-Z1*X12
ALB=XYK*XYK+XZJ*XZJ+B*YZI*YZI
R1=SQRT(X1*X1+B*Y1*Y1+B*Z1*Z1)
R2=SQRT(X2*X2+B*Y2*Y2+B*Z2*Z2)
UU=(X2*X12+B*Y2*Y12+B*Z2*Z12)/R2-(X1*X12+B*Y1*Y12+B*Z1*Z12)/R1
1 SUM=SUM+UU*YZI/ALB*SI(K,IR)
F=SUM*CH(IZ)/(8.*FJ)
RETURN
END

```

\$ FORTY

\$ INCODE IBMF

SUBROUTINE INVRX (THETA1,BONDN,AA,IPANEL,BIGCX,AK,ICW,CX)

C FIND THE INVERSE TRANSFORMATION MATRIX

DIMENSION THETA1(1),BONDN(1),AA(1),BIGCX(IPANEL,1)

DIMENSION AK(1),CX(ICW,1)

1 COMMON /ADD/ CP(100),CM(30),BREAK(8),SWP(8,15),GAL(30),ISYM,VMU,VU

1,TEMP,FCR,CAMLER,CAMLET,CAMTER,CAMTET,XJ,YJ,ZJ,RJ,ALP,CREF,TWISTR

COMMON /CLOPE/ DZDXK(100),ALPAO(15),GCB(100),GCBX(100),THETAK(10)

1,CCX(100),OZDXK(100),GAN(2,100)

COMMON /CONST/ NCS,NCW,M1(8),NSJ,NCJ(5),LAST,MJW1(3,5),MJW2(3,5),J

1PANEL,MJJ(5),NW(3),NNJ,NJP

COMMON /GEOM/ HALFSW,XCP(200),YCP(200),ZCP(200),XLE(50),YLE(50),XT

1E(50),PSI(20),CH(95),XV(200),YV(100),SN(8,8),XN(200,2),YN(200,2),

2 ZN(200,2),WIDTH(8),YCCN(25),SWEEP(50),HALFB,SJ(21,8),EX(95,2),TX(

395,2),SC(160,5),SI(160,5),LC(3)

COMMON /COST/ LTOTAL,LPAN1,NJW(5),LPANEL,IENTN,LPAN2,EXIT,PTIAL,TW

1IST,DF(5),NFP

PI=3.14159265

I=1

ISM=1

ISN=1

IFF=1

MJ=1

```

NN=NW(ISN)
MAX=(M1(ISM)-1)*NW(ISN)
DO 15 J=1,LPANEL
MI=J-IFF+1
ML=M1(ISM)
NL=NW(ISN)
FML=ML
FNL=NL
GCBX(J)=-CH(I)*WIDTH(ISM)*XV(J)/(FNL*FML*CREF)*SN(MI,ISN)*SJ(MJ,ISM)
1M)
GCB(J)=CH(I)*WIDTH(ISM)/(FNL*FML)*SN(MI,ISN)*SJ(MJ,ISM)
IF (J.LT. NN .OR. J.EQ. LPANEL) GO TO 15
I=I+1
IFF=NN+1
IF (J.EQ. LPAN1 .OR. J.EQ. LPAN2) ISN=ISN+1
NN=NN+NW(ISN)
MJ=MJ+1
IF (MJ.EQ. M1(ISM)) MJ=1
IF (J.LT.MAX) GO TO 15
ISM=ISM+1
IF (J.EQ. LPAN1 .OR. J.EQ. LPAN2) ISM=1
MAX=MAX+(M1(ISM)-1)*NW(ISN)
15 CONTINUE
NW2=NW(1)+NW(2)
IF (NW(2).EQ.0) GO TO 62
II=1+NCS
IF (NW(3).NE.0) GO TO 69
CHORD=CH(1)+CH(II)
XX1=CH(1)/CHORD
THETA1=ARCOS(1.-2.*XX1)
THETA2=PI
GO TO 63
69 III=II+NCS
CHORD=CH(1)+CH(II)+CH(III)
XX1=CH(1)/CHORD
THETA1=ARCOS(1.-2.*XX1)
XX2=(CH(1)+CH(II))/CHORD
THETA2=ARCOS(1.-2.*XX2)
GO TO 63
62 CHORD=CH(1)
63 CONTINUE
DO 61 J=1,NCW
IF (NW(2).EQ.0) GO TO 64
IF (J.LE.NW(1)) GO TO 64
IF (J.GT.NW2) GO TO 59
LL=LPAN1+J-NW(1)
GO TO 65
59 LL=LPAN2+J-NW2
GO TO 65
64 LL=J
65 CONTINUE

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```

XCK=(XV(LL)-XLE(1))/CHORD
XCI=(XCP(LL)-XLE(1))/CHORD
THETAI(J)=ARCOS(1.-2.*XCI)
THETAK(J)=ARCOS(1.-2.*XCK)
61  CONTINUE
    DO 13 K=1,NCW
    DO 13 J=1,NCW
    FM=NCW
    CX(K,J)=1./FM*(-1.)*(K+J)*SIN(THETAK(J))/(COS(THETAK(J))-COS(THET
1AI(K)))
13  CONTINUE
    ICA=ICW
    CALL SETDIM (CX,ICA,ICA)
    CALL HEMINV (CX,ICA,BOADN)
C   STORE THE INTERPOLATION MATRIX IN THE COMMON BLOCK CCX(I)
    DO 18 I=1,NCW
    DO 18 J=1,NCW
    IK=(I-1)*NCW+J
18  CCX(IK)=CX(I,J)
    RETURN
    END
$   LINK      LINK11
$   FORTY
$   LIMITS    ,31K
$   INCODE    IBMF
SUBROUTINE GEOMTY(KCODE)
C   TO SET UP THE GEOMETRY OF THE VORTEX ELEMENTS AND CONTROL POINTS
    DIMENSION XXL(5),YL(5),XXT(5),ZL(5),CPCWL(31),CPSWL(31)
    COMMON /AERO/ AM1,AM2,B1,B2,CL(30),CT(30),CD(30),GAM(2,100)
    COMMON /ADD/ CP(100),CM(30),BREAK(8),SWP(8,15),GAL(30),ISYM,VMU,VU
1,TEMP,FCR,CAMLER,CAMLET,CAMTER,CAMTET,XJ,YJ,ZJ,RJ,ALP,CREF,TWISTR
    COMMON /CONST/ NCS,NCW,M1(8),NSJ,NCJ(5),LAST,MJW1(3,5),MJW2(3,5),J
1PANEL,MJJ(5),NW(3),NNJ,NJP
    COMMON /COST/ LTOTAL,LPAN1,NJW(5),LPANEL,IENTN,LPAN2,EXIT,PTIAL,TW
1IST,DF(5),NFP
    COMMON /PARAM/ ALPT,ALPC,ALPS,CDF,SDF,TH,TDF
    COMMON /GECM/ HALFSW,XCP(200),YCP(200),ZCP(200),XLE(50),YLE(50),XT
1E(50),PSI(20),CH(95),XV(200),YV(100),SN( 8,8),XN(200,2),YN(200,2),
2 ZN(200,2),WIDTH(8),YCCN(25),SWEEP(50),HALFB,SJ(21,8),EX(95,2),TX(
395,2),SC(160,5),SI(160,5),LC(3)
    COMMON /SCHEME/ C(2),X(10,41),Y(10,41),SLOPE(15),XL(2,15),XTT(41),
1XLL(41)
1  FORMAT (3(I4,6X))
2  FORMAT (8(F10.5))
3  FORMAT (8(6X,I4))
4  FORMAT (10X,8H HALF SW=,E12.5,10X,5H CREF=,E12.5)
5  FORMAT (6(F10.5))
6  FORMAT (2(6X,I4),7F10.5)
8  FORMAT (13H CASE NUMBER =,I2)
400 FORMAT(1H0,10H INPUT DATA)
402 FORMAT(1H0,'LPANEL=',I3,3X,'JPANEL=',I3,3X,'LAST=',I3,3X,'LTOTAL='

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1,I3)
403 FORMAT(1H0,36HVORTEX ELEMENT ENDPOINT COORDINATES=)
610 FORMAT (1H0,'X1',8X,'X2',8X,'Y1',8X,'Y2',8X,'Z1',8X,'Z2',8X)
404 FORMAT(1H0,26HCONTROL POINT COORDINATES=)
620 FORMAT (1H0,'XCP',7X,'YCP',7X,'ZCP',7X,'XCP',7X,'YCP',7X,'ZCP')
405 FORMAT(1H0,42HWARNING. THE EQUIVALENT JET MACH NUMBER IS,F10.5,41H
11T HAS BEEN SET TO 0.9 IN THE COMPUTATION)
29 FORMAT (1H0,46HTHE EQUIVALENT JET PROPERTIES ARE EVALUATED AT,F10.
*5)
30 FORMAT (1H0,28HTHE EQUIVALENT JET RADIUS IS,F10.5)
36 FORMAT(/20X,50HXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX)
32 FORMAT (1H0,49HTHE VELCCITY RATIO OF THE EQUIVALENT JET,V0/VJ,IS,F
*10.5)
37 FORMAT(/20X,46HTHE JET HAS NOT WASHED THE WING. AN EQUIVALENT/20X,
148HCIRCULAR JET IS USED FOR INTERACTION COMPUTATION)
38 FCRMAT(/20X,51HTHE JET HAS WASHED THE WING. A RECTANGULAR JET WITH
1/20X,42HLATERAL EXTENT EQUAL TO THE EQUIVALENT JET/20X,44HDIAMETER
2 IS USED FOR INTERACTION COMPUTATION)
39 FORMAT(/20X,51HNOTE. CHECK WHETHER THE WING IS IMMERSSED IN THE JET
1)
WRITE (6,400)
PI=3.14159265
NCS=0
KL=0
IPANEL=1
RT=0.0
DO 28 I=1,5
28 DF(I)=0.

C
C ***MACH NUMBERS OF FREESTREAM AND JET FLOW, FREESTREAM/JET VELOCITY
C RATIO,JET/FREESTREAM TEMPERATURE RATIO,ANGLE OF ATTACK IN DEGREE.,
C WING L.E. AND T.E. X-COORDINATES AT THE JET AXIS LOCATION***
C READ (5,2) AM1,AM2,VMU,TEMP,ALP,XEL,XET
C WRITE (6,2) AM1,AM2,VMU,TEMP,ALP,XEL,XET

C
C ***NUMBER OF FLAP SECTIONS (INCLUDING THE JET SPAN), THE NUMERICAL
C ORDER OF JET SPAN AND THE CORRESPONDING FLAP DEFLECTION ANGLES IN
C DEGREES ***
C READ (5,6) NFP,NJP,(DF(I),I=1,NFP)
C WRITE (6,6) NFP,NJP,(DF(I),I=1,NFP)

C
C ***REFERENCE HALF WING AREA, DISTANCE OF FLAP HINGE FROM LOCAL L.E.
C REFERRED TO LOCAL CHORD, TWIST IN DEG., INCIDENCE OF ROOT CHORD IN
C DEG., X-, Y- AND Z- COORDINATES OF JET CENTER AT EXIT, AND JET
C RADIUS ***
C NOTE FOR USB APPLICATIONS, YJ,ZJ AND RJ MAY BE ANY NON-ZERO VALUES.
C ,UNLESS THE RECTANGULAR JET IS NOT ON THE SURFACE AND THE ENTRAIN-
C MENT EFFECT IS TO BE ACCOUNTED FOR.
C CREF - MEAN AERODYNAMIC CHORD
C READ (5,2) HALFSW,TWIST,TWISTR,XJ,YJ,ZJ,RJ,CREF
C WRITE (6,2) HALFSW,TWIST,TWISTR,XJ,YJ,ZJ,RJ,CREF

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C
C ***TRAILINF-EDGE ANGLE IN DEG., PARTIAL-SPAN FLAP INDICATOR (=0. FOR
C NO OR FULL-SPAN FLAP, AND =1. OTHERWISE), CONFIGURATION INDICATOR
C (=1. FOR USB, AND =0. FOR OWB)
C NOTE FOR USB APPLICATIONS, TEANGL MAY BE ANY VALUE *
  READ (5,2) TEANGL,PTIAL,USB
  WRITE (6,2) TEANGL,PTIAL,USB
  CAMLER=0.
  CAMLET=0.
  CAMTER=0.
  CAMTET=0.

C
  IUSB=USB
  DFJ=0.
  CMU=0.

C * THE FOLLOWING DATA ARE NOT NEEDED FOR OWB APPLICATIONS *
  IF (IUSB .NE. 1) GO TO 198

C
C *** THRUST COEFFICIENT, JET DEFLECTION ANGLE IN DEG. AND ENTRAINMENT
C CODE IF THE RECTANGULAR JET IS NOT ON THE WING SURFACE (=1. IF THE
C ENTRAINMENT DUE TO AN EQUIVALENT ROUND JET IS TO BE INCLUDED, =0.
C OTHERWISE)
  READ (5,2) CMU,DFJ,TNJ
  WRITE (6,2) CMU,DFJ,TNJ

C
198 CONTINUE
  DFJ=DFJ*PI/180.
  DO 25 I=1,5
25  DF(I)=DF(I)*PI/180.
  TDF=DF(NJP)
  ALP=ALP*PI/180.
  ALPS=SIN(ALP)
  ALPC=COS(ALP)
  ALPT=ALPS/ALPC
  DE=TEANGL*PI/180.+TDF
  IF (IUSB .EQ. 1) CDF=DFJ
  EXIT=0.
  IF (XJ .GT. XEL) EXIT=1.
  XEL=(XEL-XJ)/RJ
  XET=(XET-XJ)/RJ
  Z=ZJ/RJ
  TH=0.
  M1(4)=0
  ITN=TNJ
  YCON(23)=TNJ
  IF (IUSB .EQ. 1 .AND. ITN .EQ. 0) GO TO 199
  CALL ENTRN (VMU,AM2,TEMP,XM,CU,RT,XEL,XET,Z,KCODE,XJC)
  XEQUI=XM*RJ+XJ
  REQUI=RT*RJ
  RT=REQUI
  IF (IUSB .EQ. 1) GO TO 199

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```

IF (XEL .LT. 0. .AND. ZJ .GE. (2.*RJ)) KCODE=0
IF (ZJ .GE. (3.*RJ)) KCODE=0
F1=-29.5428*CU*CU+33.7371*CU-8.9148
IF (CU .GT. 0.6339) F1=0.6+0.4*(CU-0.6339)/0.3661
IF (F1 .LT. 0. .AND. ZJ .GE. (1.9*RJ)) KCODE=0
IF (KCODE .EQ. 0) GO TO 199
ZR=PI*RT/2.
TH=ZR
199 CONTINUE
IF (IUSB .EQ. 1) KCODE=1
IF (IUSB .NE. 1 .AND. KCODE .EQ. 1) GO TO 197
GO TO 196
197 AX=XEL*RJ
DJX=2.*RJ
IF (F1 .LT. 0.) F1=0.
IF (ZJ .LT. (2.*RJ) .AND. ZJ .GE. (1.5*RJ)) F1=F1+(1.-F1)*(2.*RJ-
1ZJ)/(0.5*RJ)
IF (ZJ .LT. (1.5*RJ)) F1=1.
IF (F1 .GT. 1.) F1=1.
FACT=F1
CDF=DE*FACT
196 CONTINUE
C
C *** TOTAL NUMBER OF SPANWISE SECTIONS, AND THE NUMBER OF VORTEX
C STRIPS IN EACH SECTION PLUS 1 ***
C * THE NUMBER OF VORTEX STRIPS IN THE JET REGION SHOULD BE CONSISTENT
C WITH THAT OF JET VORTEX STRIPS *
READ (5,3) NC,(M1(I),I=1,NC)
WRITE (6,3) NC,(M1(I),I=1,NC)
C
C ***THE NUMERICAL ORDER OF FLAP AND JET SPANS AMONG THE SPANWISE
C SECTIONS ***
READ (5,3) (NJW(I),I=1,NFP)
WRITE (6,3) (NJW(I),I=1,NFP)
C
C *** NUMBER OF CHORDWISE VORTEX ELEMENTS IN CHORDWISE SECTIONS ***
READ (5,3) (NW(I),I=1,3)
WRITE (6,3) (NW(I),I=1,3)
C
NCW=NW(1)
L=1
105 CONTINUE
LL=1
FN=NCW
DO 100 I=1,NCW
FI=I
CPCWL(I)=0.5*(1.-COS((2.*FI-1.)*PI/(2.*FN)))
SN(I,L)=2.*SQRT(CPCWL(I)*(1.-CPCWL(I)))
100 CPCWL(I)=CPCWL(I)*100.
DO 10 KK=1,NC

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```

C *** COORDINATES OF BREAK CHORDS BOUNDING SPANWISE SECTIONS ***
  READ (5,2) (XXL(I),XXT(I),YL(I),I=1,2)
  WRITE (6,2) (XXL(I),XXT(I),YL(I),I=1,2)

C
  IF (IUSB .EQ. 1) GO TO 113
  IF (ISYM .EQ. 0 .AND. KK .EQ. 1) GO TO 99
  IF (KK .EQ. (NJW(NJP)+1)) GO TO 103
  IF (ISYM .NE. 0 .AND. KK .EQ. (NJW(NJP)-1)) GO TO 102
  IF (ISYM .NE. 0 .AND. KK .EQ. NJW(NJP)) GO TO 99
  GO TO 113
99 XXL(2)=XXL(1)+(XXL(2)-XXL(1))*(YL(2)-YL(1)+RT-RJ)/(YL(2)-YL(1))
  XXT(2)=XXT(1)+(XXT(2)-XXT(1))*(YL(2)-YL(1)+RT-RJ)/(YL(2)-YL(1))
  IF (ISYM .EQ. 0) GO TO 104
103 XXL(1)=XL2
  XXT(1)=XT2
  GO TO 104
102 XXL(2)=XXL(1)+(XXL(2)-XXL(1))*(YL(2)-YL(1)-RT+RJ)/(YL(2)-YL(1))
  XXT(2)=XXT(1)+(XXT(2)-XXT(1))*(YL(2)-YL(1)-RT+RJ)/(YL(2)-YL(1))
104 XL2=XXL(2)
  XT2=XXT(2)
  IF (ISYM .EQ. 0 .AND. KK .EQ. 1) GO TO 112
  IF (ISYM .NE. 0 .AND. KK .EQ. (NJW(NJP)-1)) GO TO 112
  YL(1)=YL2
112 IF (ISYM .EQ. 0) GO TO 101
  IF (KK .EQ. (NJW(NJP)+1)) GO TO 113
  IF (KK .EQ. NJW(NJP)) YL(2)=YL(2)+RT-RJ
  IF (KK .EQ. (NJW(NJP)-1)) YL(2)=YL(2)-RT+RJ
  GO TO 111
101 IF (KK .EQ. 1) YL(2)=YL(2)+RT-RJ
111 YL2=YL(2)
113 CONTINUE
  FM=M1(KK)
  NSW=M1(KK)
  DO 120 J=1,NSW
    FJ=J
    CPSWL(J)=0.5*(1.-COS((2.*FJ-1.)*PI/(2.*FM)))*100.
    YCON(J)=0.5*(1.-COS(FJ*PI/FM))
    SJ(J,KK)=SIN(FJ*PI/FM)
120 CONTINUE
  IF (KK .EQ. NC) GO TO 130
  CPSWL(1)=0.
  CPSWL(NSW)=100.
  GO TO 135
130 CPSWL(1)=0.
135 IF (KK .EQ. NJW(LL)) MJW1(L,LL)=IPANEL
  IF (KK .EQ. NJW(NJP)) LC(L)=KL+1
  LR=(L-1)*NC+KK
  CALL PANEL(XXL,YL,XXT,CPCWL,CPSWL,NSW,IPANEL,LPANEL,KL,LR,SWP)
  IPANEL=LPANEL+1
  NCS=NCS+NSW-1
  WIDTH(KK)=YL(2)-YL(1)

```

```

BREAK(KK)=YL(1)
IF (KK .EQ. NJW(LL)) MJW2(L,LL)=LPANEL
IF (KK .NE. NC) GO TO 10
HALFB=YL(2)
10 IF (KK .EQ. NJW(LL)) LL=LL+1
IF (L .EQ. 3) GO TO 107
IF (L .EQ. 1) LPAN1=LPANEL
IF (L .EQ. 2) LPAN2=LPANEL
IF (NW(2) .EQ. 0) GO TO 106
L=L+1
NCW=NW(L)
IF (L .EQ. 3 .AND. NW(3) .EQ. 0) GO TO 108
GO TO 105
106 DO 23 I=2,3
DO 23 J=1,NFP
MJW1(I,J)=0
23 MJW2(I,J)=0
LPAN2=LPANEL
NCS=NCS*3
GO TO 107
108 DO 24 I=1,NFP
MJW1(3,I)=0
24 MJW2(3,I)=0
L=L-1
NCS=NCS+NCS/2
107 CONTINUE
NCS=NCS/3
NCW=NCW(1)+NW(2)+NW(3)
VU=VMU
IF (IUSB .EQ. 1) CU=VMU
VMU=CU
RTJ=RJ
ZJT=ZJ
IF (RT .GT. ZJ .AND. KCODE .EQ. 0) ZJT=RT
IF (IUSB .EQ. 1) GO TO 109
AM2=AM1/(VMU*SQRT(TEMP))
IF (AM2 .GT. 0.9) WRITE (6,405) AM2
IF (AM2 .GT. 0.9) AM2=0.9
109 CONTINUE
LAST=LPANEL

```

```

C
C *** TOTAL NUMBER OF STREAMWISE JET SECTIONS, NUMBER OF JET CIRCUM-
C FERENTIAL STRIPS PLUS ONE( USE ODD NUMBERS FOR A NON-CENTERED JET
C AND EVEN NUMBERS FOR A CENTERED JET), AND NUMBERS OF JET VORTEX
C ELEMENTS ON EACH JET SECTION ***
READ (5,3) NNJ,NSJ,(NCJ(I),I=1,NNJ)
WRITE (6,3) NNJ,NSJ,(NCJ(I),I=1,NNJ)
C
IF (KCODE .EQ. 0) CALL CIRCJ(ISYM,NSJ,Y)
IF (ISYM .EQ. 0) NSJJ=NSJ/2
IF (ISYM .NE. 0) NSJJ=(NSJ+1)/2

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```

NSYM=1-ISYM
NSJ1=NSJJ-1
FNJ=NSJJ
CPSWL(1)=0.
CPSWL(NSJJ)=1.
YCON(1)=0.5*(1.-COS(PI/FNJ))
DO 33 I=2,NSJ1
  FI=I
  CPSWL(I)=0.5*(1.-COS((2.*FI-1.)*PI/(2.*FNJ)))
33 YCON(I)=0.5*(1.-COS(FI*PI/FNJ))
  IENTN=NC
  JC=NCS*L
  NJ1=NNJ-1
  DO 11 JJ=1,NNJ
    IF (IUSB .EQ. 1) GO TO 122
C
C   *** COORDINATES OF BOUNDING LINES OF JET SECTIONS PROJECTED ON X-Y
C   PLANE ***
  READ (5,2) (XXL(I),XXT(I),YL(I),I=1,2)
  WRITE (6,2) (XXL(I),XXT(I),YL(I),I=1,2)
C
  IF (ISYM .EQ. 0) GO TO 98
  XL1=XXL(1)-(XXL(2)-XXL(1))*(RT-RTJ)/(YL(2)-YL(1))
  XT1=XXT(1)-(XXT(2)-XXT(1))*(RT-RTJ)/(YL(2)-YL(1))
98  XL2=XXL(1)+(XXL(2)-XXL(1))*(RT+RTJ)/(YL(2)-YL(1))
  XT2=XXT(1)+(XXT(2)-XXT(1))*(RT+RTJ)/(YL(2)-YL(1))
  IF (ISYM .EQ. 0) GO TO 97
  XXL(1)=XL1
  XXT(1)=XT1
97  XXL(2)=XL2
  XXT(2)=XT2
  IF (ISYM .EQ. 0) GO TO 96
  YL(1)=YL(1)-RT+RTJ
96  YL(2)=YL(2)+RT-RTJ
  IF (KCODE .EQ. 0) GO TO 13
  XXL(4)=XXL(2)
  XXT(4)=XXT(2)
  YL(4)=YL(2)
  XXL(2)=XXL(1)
  XXT(2)=XXT(1)
  YL(2)=YL(1)
  XXL(3)=XXL(4)
  XXT(3)=XXT(4)
  YL(3)=YL(4)
  ZL(1)=0.
  ZL(2)=ZR
  ZL(3)=ZR
  ZL(4)=0.
13  CONTINUE
  GO TO 121
C

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```

C ***COORDINATES OF BREAK POINTS DEFINING RECTANGULAR JET SECTIONS FOR
C USB CONFIGURATIONS***
C
122 DO 123 I=1,4
    READ (5,2) XXL(I),XXT(I),YL(I),ZL(I)
123 WRITE (6,2) XXL(I),XXT(I),YL(I),ZL(I)
121 CONTINUE
    II=JJ
    JJ1=JJ+L
    FNCJ=NCJ(JJ)
    NJ=NCJ(JJ)
    NMJ=NJ*16
    IF (NJ .GT. 6) NMJ=NJ*8
    FNJ=NMJ
    DO 1000 J=1,NMJ
        FJ=J
        SC(J,JJ)=0.5*(1.-COS((2.*FJ-1.)*PI/(2.*FNJ)))
1000 SI(J,JJ)=SIN((2.*FJ-1.)*PI/(2.*FNJ))
        DO 12 J=1,NJ
            FJ=J
            CPCWL(J)=0.5*(1.-COS((2.*FJ-1.)*PI/(2.*FNCJ)))
12 SN(J,JJ1)=2.*SQRT(CPCWL(J)*(1.-CPCWL(J)))
            IF (KCODE .EQ. 0) CALL JSHAPE(XXL,XXT,YL,YJ,ZJT,RT,CPCWL,IPANEL,NJ
1,JC,ISYM)
            IF (KCODE .EQ. 1) CALL RESHAP(XXL,XXT,YL,ZL,CPCWL,CPSWL,IPANEL,NJ,
1JC,II,NSYM)
            MJJ(JJ)=LAST
11 IPANEL=LAST+1
21 CONTINUE
    SDF=XXT(1)-XXL(1)
    IF (IUSB .EQ. 1) TH=ZL(3)-ZL(4)
    YCON(25)=ZL(4)
    YCON(24)=USB
    C(1)=CMU
    IF (KCODE .EQ. 0) YCON(25)=1.
    IF (KCODE .EQ. 1) CALL RECTJ(ISYM,NSJ,Y)
    WRITE (6,4) HALFSW,CREF
    JPANEL=LAST-LPANEL
    LTOTAL=LAST+JPANEL
    WRITE (6,402) LPANEL,JPANEL,LAST,LTOTAL
    IF (IUSB .EQ. 1) GO TO 124
    WRITE (6,36)
    IF (KCODE .EQ. 0) WRITE (6,37)
    IF (KCODE .EQ. 1) WRITE (6,38)
    IF (KCODE .EQ. 1) WRITE (6,39)
    WRITE (6,36)
    WRITE (6,29) XEQUI
    WRITE (6,30) REQUI
    WRITE (6,32) VMU
124 CONTINUE
    WRITE (6,403)

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WRITE (6,610)
WRITE (6,5) (XN(I,1),XN(I,2),YN(I,1),YN(I,2),ZN(I,1),ZN(I,2),I=1,L
1AST)
WRITE (6,404)
WRITE (6,620)
WRITE (6,5) (XCP(I),YCP(I),ZCP(I),I=1, LAST)
IF (KCODE .EQ. 1) GO TO 2022
IF (ISYM .EQ. 0) GO TO 2021
FN2=(NSJ-1)/2+1
NJH=(NSJ-1)/2+2
ANG=PI/(2.*FN2)
FAC=(SIN(3.*ANG)-SIN(ANG)/COS(ANG))/(1.-COS(3.*ANG))
PHI=PI/2.-ATAN(FAC)
NJH1=NJH-1
NJH2=NJH+1
Y(3,2)=SIN(PHI)
Y(4,2)=-COS(PHI)
Y(3,NJH1)=Y(3,2)
Y(4,NJH1)=-Y(4,2)
Y(3,NJH2)=-Y(3,2)
Y(4,NJH2)=Y(4,2)
Y(3,NSJ1)=-Y(3,2)
Y(4,NSJ1)=-Y(4,2)
GO TO 2022
2021 FN2=NSJ/2
NJH=NSJ/2
ANG1=1.-0.5*(1.-COS(PI/(2.*FN2)))
ANG3=1.-0.5*(1.-COS(3.*PI/(2.*FN2)))
ANG1=ATAN(SQRT(1.-ANG1*ANG1)/ANG1)
ANG3=ATAN(SQRT(1.-ANG3*ANG3)/ANG3)
FAC=(SIN(ANG3)-SIN(ANG1)/COS(ANG1))/(1.-COS(ANG3))
PHI=PI/2.-ATAN(FAC)
NJH1=NJH-1
NJH2=NSJ1
Y(3,NJH1)=SIN(PHI)
Y(4,NJH1)=COS(PHI)
Y(3,NJH2)=-Y(3,NJH1)
Y(4,NJH2)=Y(4,NJH1)
2022 CONTINUE
FNJ=NCJ(NNJ)
NPJ=NCJ(NNJ)
DO 777 J=1,NPJ
FJ=J
777 PSI(J)=SIN(FJ*PI/FNJ)
22 CONTINUE
BETA1=SQRT(1.-AM1*AM1)
BETA2=SQRT(1.-AM2*AM2)
B1=BETA1*BETA1
B2=BETA2*BETA2
DO 951 KK=1,NCS
XLL(KK)=ALP+(TWISTR+TWIST*YLE(KK)/HALFB)*PI/180.

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      T=XLL(KK)
951  XTT(KK)=SIN(T)/COS(T)
      RETURN
      END
$    FORTY
$    INCODE  IBMF
C    SUBROUTINE RESHAP(XXL,XTT,YL,ZL,CPCWL,CPSWL,IPANEL,NJ,JC,JJ,NSYM)
      TO DEFINE THE LOCATIONS OF VORTEX AND CONTROL POINTS ON RECT. JETS
      DIMENSION XXL(1),YL(1),XTT(1),ZL(1),CPCWL(1),CPSWL(1)
      COMMON /CONST/ NCS,NCW,M1(8),NSJ,NCJ(5),LAST,MJW1(3,5),MJW2(3,5),J
1    IPANEL,MJJ(5),NW(3),NNJ,NJP
      COMMON /GEOM/ HALFSW,XCP(200),YCP(200),ZCP(200),XLE(50),YLE(50),XT
1    E(50),PSI(20),CH(95),XV(200),YV(100),SN( 8,8),XN(200,2),YN(200,2),
2    ZN(200,2),WIDTH(8),YCON(25),SWEEP(50),HALFB,SJ(21,8),EX(95,2),TX(
3    395,2),SC(160,5),SI(160,5),LC(3)
      COMMON /SCHEME/ C(2),X(10,41),Y(10,41),SLOPE(15),XL(2,15),XTT(41),
1    XLL(41)
      PI=3.14159265
      IF (NSYM .EQ. 0) NSJJ=(NSJ+1)/2
      IF (NSYM .NE. 0) NSJJ=NSJ/2
      NSJ1=NSJJ-1
      DO 1 J=1,NJ
      FJ=J
      FNJ=NJ
1    PSI(J)=0.5*(1.-COS(FJ*PI/FNJ))
      DO 2 IS=1,4
      IF (NSYM .EQ. 1 .AND. IS .EQ. 1) GO TO 2
      IF (IS .EQ. 4) GO TO 6C
      K1=IS
      K2=IS+1
      GO TO 61
60  K1=1
      K2=4
61  CONTINUE
      SPAN=YL(K2)-YL(K1)
      XDIF=XXL(K2)-XXL(K1)
      DO 3 I=1,2
      II=I+K1-1
      IF (IS .EQ. 4 .AND. I .EQ. 2) II=4
      C(I)=XTT(II)-XXL(II)
      DO 3 J=1,NJ
3    XL(I,J)=XXL(II)+CPCWL(J)*C(I)
      IF (ABS(SPAN) .LE. 0.001) GO TO 10
      DO 25 J=1,NJ
25  SLOPE(J)=(XL(2,J)-XL(1,J))/SPAN
      DO 30 K=1,NSJJ
      YK=CPSWL(K)*SPAN
      DO 30 J=1,NJ
      Y(J,K)=YK+YL(K1)
      X(J,K)=XL(1,J)+SLOPE(J)*(Y(J,K)-YL(K1))
30  CONTINUE

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NS=NSJ1
10 IF (ABS(SPAN) .LE. 0.001) NS=1
   DO 35 K=1,NS
   YC=YCON(K)
   IF (ABS(SPAN) .LE. 0.001) YC=0.5
   KK=JC+K
   CH(KK)=C(1)-(C(1)-C(2))*YC
   IF (ABS(SPAN) .LE. 0.001) GO TO 70
   YC1=CPSWL(K)
   YC2=CPSWL(K+1)
   GO TO 71
70 YC1=0.
   YC2=1.
71 CONTINUE
   EX(KK,1)=XXL(K1)+XDIF*YC1
   EX(KK,2)=XXL(K1)+XDIF*YC2
   TX(KK,1)=XXT(K1)+(XXT(K2)-XXT(K1))*YC1
   TX(KK,2)=XXT(K1)+(XXT(K2)-XXT(K1))*YC2
   DO 35 J=1,NJ
   NPANEL=(K-1)*NJ+J-1+IPANEL
   NPAN1=NPANEL-1
   DO 40 I=1,2
   KI1=K+I-1
   IF (ABS(SPAN) .LE. 0.001) GO TO 42
   X1=X(J,KI1)
   Y1=Y(J,KI1)
   IF (J .NE. 1) GO TO 44
   ZZ=ZL(K1)+(ZL(K2)-ZL(K1))*(Y1-YL(K1))/SPAN
   XX=XDIF*(Y1-YL(K1))/SPAN+XXL(K1)
   GO TO 46
42 IZN=K1
   IF (I .EQ. 2) IZN=K2
   X1=XL(I,J)
   Y1=YL(K1)
   IF (J .NE. 1) GO TO 44
   ZZ=ZL(IZN)
   XX=XXL(IZN)
   GO TO 46
44 ZZ=ZN(NPAN1,I)
   XX=XN(NPAN1,I)
46 XN(NPANEL,I)=X1
   YN(NPANEL,I)=Y1
   ZN(NPANEL,I)=ZZ
40 CONTINUE
   XD=XDIF*YC+XXL(K1)
   XCP(NPANEL)=XD+CH(KK)*FSI(J)
   YCP(NPANEL)=YC*SPAN+YL(K1)
   IF (ABS(SPAN) .LE. 0.001) GO TO 50
   ZC=ZN(NPANEL,1)+(ZN(NPANEL,1)-ZN(NPANEL,2))*(YCP(NPANEL)-YN(NPANEL
1,1))/(YN(NPANEL,1)-YN(NPANEL,2))
   XC=XN(NPANEL,1)+SLOPE(J)*(YCP(NPANEL)-YN(NPANEL,1))

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GO TO 55
50 ZC=0.5*(ZN(NPANEL,1)+ZN(NPANEL,2))
   XC=0.5*(XN(NPANEL,1)+XN(NPANEL,2))
55 ZCP(NPANEL)=ZC
   XV(NPANEL)=XC
35 CONTINUE
   IPANEL=NPANEL+1
   LAST=NPANEL
   JC=KK
2 CONTINUE
   RETURN
   END
$   FORTY
$   INCODE   IBMF
SUBROUTINE PANEL(XXL,YL,XXT,CPCWL,CPSWL,NSW,IPANEL,LPANEL,KK,LR,
1SWP)
C   TO DEFINE THE LOCATIONS OF VORTEX AND CONTROL POINTS ON THE WING
   DIMENSION XXL(1),YL(1),XXT(1),CPCWL(1),CPSWL(1)
   DIMENSION SWP(8,15)
   COMMON /CONST/ NCS,NCW,M1(8),NSJ,NCJ(5),LAST,MJW1(3,5),MJW2(3,5),J
1IPANEL,MJJ(5),NW(3),NNJ,NJP
   COMMON /GEOM/ HALFSW,XCP(200),YCP(200),ZCP(200),XLE(50),YLE(50),XT
1E(50),PSI(20),CH(95),XV(200),YV(100),SN( 8,8),XN(200,2),YN(200,2),
2 ZN(200,2),WIDTH(8),YCON(25),SWEEP(50),HALFB,SJ(21,8),EX(95,2),TX(
395,2),SC(160,5),SI(160,5),LC(3)
   COMMON /SCHEME/ C(2),X(10,41),Y(10,41),SLOPE(15),XL(2,15),XTT(41),
1XLL(41)
   PI=3.14159265
   NSW1=NSW-1
   DO 1 I=1,2
     C(I)=XXT(I)-XXL(I)
   DO 1 J=1,NCW
1 XL(I,J)=XXL(I)+CPCWL(J)*C(I)/100.
   SPAN=YL(2)-YL(1)
   DO 2 J=1,NCW
     PSI(J)=0.5*(1.-COS(FLOAT(J)*PI/FLOAT(NCW)))
     SLOPE(J)=(XL(2,J)-XL(1,J))/SPAN
2 SWP(J,LR)=ATAN(SLOPE(J))
   DO 3 K=1,NSW
     YK=CPSWL(K)*SPAN/100.
   DO 3 J=1,NCW
     Y(J,K)=YK+YL(1)
     X(J,K)=XL(1,J)+SLOPE(J)*(Y(J,K)-YL(1))
3 CONTINUE
   XLL(1)=XXL(1)
   XTT(1)=XXT(1)
   DO 15 I=2,NSW
     XLL(I)=XLL(I-1)+(XXL(2)-XXL(1))*(Y(1,I)-Y(1,I-1))/SPAN
15 XTT(I)=XTT(I-1)+(XXT(2)-XXT(1))*(Y(1,I)-Y(1,I-1))/SPAN
   DO 6 K=1,NSW1
     KK=NCS+K

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YLE(KK)=YCON(K)*SPAN+YL(1)
XLE(KK)=XLL(K)+(XLL(K+1)-XLL(K))*(YLE(KK)-Y(1,K))/(Y(1,K+1)-Y(1,K)
1)
XTE(KK)=XTT(K)+(XTT(K+1)-XTT(K))*(YLE(KK)-Y(1,K))/(Y(1,K+1)-Y(1,K)
1)
CH(KK)=XTE(KK)-XLE(KK)
EX(KK,1)=XXL(1)+(XXL(2)-XXL(1))*CPSWL(K)/100.
EX(KK,2)=XXL(1)+(XXL(2)-XXL(1))*CPSWL(K+1)/100.
TX(KK,1)=XXT(1)+(XXT(2)-XXT(1))*CPSWL(K)/100.
TX(KK,2)=XXT(1)+(XXT(2)-XXT(1))*CPSWL(K+1)/100.
TANG=(XXL(2)-XXL(1))/SPAN
SWEEP(KK)=ATAN(TANG)
DO 6 J=1,NCW
NPANEL=(K-1)*NCW +J-1+IPANEL
DO 5 I=1,2
KI1=K+I-1
4 XN(NPANEL,I)=X(J,KI1)
YN(NPANEL,I)=Y(J,KI1)
ZN(NPANEL,I)=0.
5 CONTINUE
XCP(NPANEL)=XLE(KK)+PSI(J)*CH(KK)
YCP(NPANEL)=YLE(KK)
ZCP(NPANEL)=0.
XV(NPANEL)=XLE(KK)+CPCWL(J)*CH(KK)/100.
YV(NPANEL)=YLE(KK)
6 CONTINUE
LPANEL=NPANEL
RETURN
END
$ FORTY
$ LIMITS ,28K
$ INCODE IBMF
SUBROUTINE ENTRN (U,AMJ,T,XM,CMU,RT,XEL,XET,Z,KCODE,XJC)
C TO COMPUTE THE JET ENTRAINMENT FUNCTION
DIMENSION CSJ(70),SSJ(70)
DIMENSION PU1(31),PU2(31),FU1(31),FU2(31),FU3(31),RR2(31)
COMMON /JET/ PK1,XC,X(31),A(31),B(31)
C
55 FORMAT(8F10.5)
PI=3.14159265
IK=1
REJ=T
PK1=0.0185+0.011*U
KCODE=0
XMID=0.5*(XEL+XET)
XM=XMID
X0=0.
R0=1.
F=2.*PK1*SQRT((1.-U)*REJ)
XC=0.35/F
XJC=XC

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AG2=ALOG((1.+2.*U/AK2)/(1.+U/AK2))
DSX1=2.*PK1/0.72*SQRT(REJ*(1.-U)*AK2*AG2/U)
DX=X(I)-XH
S=S+DX*DSX1
M=M+1
GO TO 10
5 IF (I .NE. 1) SH=2.*PK1*SQRT(REJ)*X(I)-0.35
  IF (I .NE. 1) P1=(1.-U)*(1.-EXP(-1./(2.*SH)))
  DSX=2.*PK1*SQRT(REJ)
  IF (ABS(T-1.) .LE. 0.01) GO TO 20
  S=2.*PK1/0.72*SQRT(REJ)*X(I)-0.35
15 IF (I .EQ. 1 .AND. U .GT. 0.01) DSX=2.*PK1*SQRT(REJ*ALOG(UA)/U)*
  1(1.-U)
  H0=1.-EXP(-1./(2.*S))
  HOP=-2.*H0**2/0.72
  P2=(T-1.+0.2*(1.-U*U)*AMJ*AMJ*T)*H0-0.2*P1*AMJ*AMJ*T*(P1+2.*U)
  P2P=(T-1.+0.2*(1.-U*U)*AMJ*AMJ*T)*HOP-0.2*P1P*AMJ*AMJ*T*(P1+2.*U)
  1-0.2*P1*AMJ*AMJ*T*P1P
  F1P=-P2P*0.8907*(0.08901-0.04005*P2+0.01792*P2**2-0.00646*P2**3)/(
  11.+1.05001*P2)
  F2P=-P2P*0.79335*(0.0527-0.02886*P2+0.01478*P2**2-0.00589*P2**3)/
  1(1.+1.08869*P2)
  F3P=-P2P*(0.12857-0.04653*P2+0.01820*P2**2-0.00599*P2**3)/(1.
  1+1.02272*P2)
  GO TO 25
20 P2=0.
  P2P=0.
  F1P=0.
  F2P=0.
  F3P=0.
  IF (I .EQ. 1 .AND. U .GT. 0.01) DSX=2.*PK1*SQRT(REJ*ALOG(UA)/U)*
  1(1.-U)
25 P1P=-2.*P1*P1/(1.-U)
  F1=0.8907*(0.12857+0.01617*P2-0.00607*P2**2+0.00192*P2**3)/(1.
  1+0.81817*P2)
  F2=0.79335*(0.06676+0.00453*P2-0.00204*P2**2+0.00075*P2**3)/(1.
  1+0.85716*P2)
  F3=(0.21429+0.04061*P2-0.01249*P2**2+0.00351*P2**3)/(1.+0.78948*
  1P2)
  FU=U*P1+F1+P1*P1*F2
  DMC1=(P1P*F1+P1*F1P-U*F2P*F3-U*P2*F3P)/FU
  DMC2=(P1*F1-U*P2*F3)*(U*P1P*F1+U*P1*F1P+2.*P1*P1P*F2+P1*P1*F2P)
  1/(FU*FU)
  DMX=2.*(1.-U)*(DMC1-DMC2)*DSX/SQRT(REJ)
  RJ2=0.5*(1.-U)/FU
  RJ1=SQRT(RJ2)
  WRITE (6,55) X(I),RJ1,DMX
  IF (IK .GT. 1) GO TO 28
  IF (X(I) .GE. XEL) GO TO 26
  GO TO 28
26 IF (RJ1 .LT. 2) GO TO 28

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P1=1.-U
UA=(1.+2.*U/(1.-U))/(1.+U/(1.-U))
X(1)=XC
DXX=(3.*XET-XEL)/30.
IDX=DXX
DXX=IDX
IF (DXX .GT. 3.) GO TO 11
  IF (DXX .GE. 1. .AND. DXX .LE. 3.) DXX=2.5
  IF (DXX .LT. 1.) DXX=1.5
11 CONTINUE
X(2)=X(1)+DXX/2.
DO 1 I=2,30
  1 X(I+1)=X(I)+DXX
  DO 2 I=1,70
    FI=I
    CSJ(I)=COS((2.*FI-1.)*PI/140.)
  2 SSJ(I)=SIN((2.*FI-1.)*PI/140.)
  DO 3 I=1,31
    IF (U .LE. 0.01) GO TO 5
    IF (I .EQ. 1 .AND. ABS(T-1.) .LE. 0.01) GO TO 20
    IF (I .EQ. 1) S=(2.*PK1*SQRT(REJ*(1.-U))*XC/0.72-0.35)*SQRT((1.-U)
1/U*ALOG(UA))
    IF (I .EQ. 2) S=DSX*(X(2)-XC)
    IF (I .GT. 2) S=SH+DSX*DXX
    M=1
    IF (I .EQ. 1) M=2
10 CONTINUE
SUM=0.
DO 4 J=1,70
  SB=0.5*S*(1.-CSJ(J))
  AP1=(1.-U)*(1.-EXP(-1./(2.*SB)))
  AG=ALOG((1.+2.*U/AP1)/(1.+U/AP1))
  4 SUM=SUM+(1./SQRT(AP1*AG)-SQRT(2.*SB/((1.-U)*0.69314718)))*SSJ(J)
  RES=SUM*PI/70.*0.5*S*SQRT(U)+SQRT(2.*U/(1.-U))*S*1.5/1.0397208
  X1=RES+0.35
  IF (M .NE. 1) GO TO 30
  XT=X1/(2.*PK1*SQRT((1.-U)*REJ))
  P1=(1.-U)*(1.-EXP(-1./(2.*S)))
  G1=ALOG((1.+2.*U/P1)/(1.+U/P1))
  DSX=2.*PK1*SQRT(REJ*(1.-U)*P1*G1/U)
  SH=S
  IF (ABS(X(I)-XT) .LE. 0.01) GO TO 35
  DX=X(I)-XT
  S=S+DX*DSX
  SH=S
  GO TO 10
35 P1=(1.-U)*(1.-EXP(-1./(2.*SH)))
30 IF (ABS(T-1.) .LE. 0.01) GO TO 20
  XH=X1*0.72/(2.*PK1*SQRT((1.-U)*REJ))
  IF (ABS(X(I)-XH) .LE. 0.01) GO TO 15
  AK2=(1.-U)*(1.-EXP(-1./(2.*S)))

```

```

XMJ=X0+(Z-R0)*(X(I)-X0)/(RJ1-R0)
IF (XEL .LT. 0) GO TO 29
IF (XMJ .LT. XET) KCODE=1
IK=IK+1
GO TO 28
29 XM=0.5*XET
IF (XMJ .LE. XM) KCODE=1
IK=IK+1
28 CONTINUE
RC=RJ1
X0=X(I)
PU1(I)=P1
PU2(I)=P2
FU1(I)=F1
FU2(I)=F2
FU3(I)=F3
RR2(I)=RJ2
IF (I .EQ. 1) GO TO 40
B(I)=(DMX-DMX0)/(X(I+1)-X(I))
A(I)=DMX0-B(I)*X(I)
GO TO 3
40 A(I)=0.145*DMX/0.32
B(I)=(DMX-A(I))/XC
3 DMX0=DMX
K=1
50 IF (K .GT. 30) GO TO 65
IF (XM .GE. 0. .AND. XM .LT. XC) GO TO 60
IF (XM .GE. X(K) .AND. XM .LT. X(K+1)) GO TO 60
K=K+1
GO TO 50
60 F11=RR2(K)*(PU1(K)*U*FU1(K)+PU1(K)**2*FU2(K))/(U*U)
F12=RR2(K+1)*(PU1(K+1)*U*FU1(K+1)+PU1(K+1)**2*FU2(K+1))/(U*U)
F21=RR2(K)*(PU1(K)*FU1(K)-U*PU2(K)*FU3(K))/U
F22=RR2(K+1)*(PU1(K+1)*FU1(K+1)-U*PU2(K+1)*FU3(K+1))/U
IF (ABS(T-1.) .LE. 0.001) GO TO 61
F31=RR2(K)*(9.*PU1(K)/70.-PU1(K)*FU1(K)+U*PU2(K)*FU3(K))/U
F32=RR2(K+1)*(9.*PU1(K+1)/70.-PU1(K+1)*FU1(K+1)+U*PU2(K+1)*FU3(K+1))/U
X11=F11/(F21+F31)
X12=F12/(F22+F32)
GO TO 62
61 F31=0.
F32=0.
62 CONTINUE
X1=X(K)
X2=X(K+1)
X21=F11/(F21+F31)+F31*(F11/(F21+F31)-1.)/F21
X22=F12/(F22+F32)+F32*(F12/(F22+F32)-1.)/F22
X31=2.*F21*(F21+F31)/(F11-F21-F31)
X31=SQRT(X31)
X32=2.*F22*(F22+F32)/(F12-F22-F32)

```



```

X32=SQRT(X32)
IF (XM .GE. 0. .AND. XM .LT. XC) GO TO 70
GO TO 75
70 X1=0.
X2=XC
X22=X21
X32=X31
X21=1./U
X12=X11
X31=1.
IF (ABS(T-1.) .LE. 0.001) GO TO 75
X11=1./(T*U)
75 CMU=X21+(XM-X1)*(X22-X21)/(X2-X1)
RT=X31+(XM-X1)*(X32-X31)/(X2-X1)
CMU=1./CMU
IF (ABS(T-1.) .LE. 0.001) GO TO 63
RU=X11+(XM-X1)*(X12-X11)/(X2-X1)
T=1./(CMU*RU)
WRITE (6,55) T,CMU,RU,XM
63 CONTINUE
65 CONTINUE
RETURN
END
$ FORTY
$ INCODE IBMF
SUBROUTINE RECTJ(ISYM,NSJ,Y)
TO DEFINE THE UNIT NORMAL VECTORS TO THE SURFACE OF RECTANGULAR
C JETS
C
DIMENSION Y(10,41)
IF (ISYM .EQ. 0) GO TO 1
NSJ1=NSJ+1
NJH=(NSJ-1)/2+2
GO TO 5
1 NSJ1=NSJ-1
NJH=NSJ/2
5 DO 10 I=1,NSJ1
IF (I .EQ. 1 .AND. ISYM .NE. 0) GO TO 15
IF (I .EQ. NJH) GO TO 20
Y(3,I)=1.
Y(4,I)=0.
GO TO 10
15 Y(3,I)=0.
Y(4,I)=-1.
GO TO 10
20 Y(3,I)=0.
Y(4,I)=1.
10 CONTINUE
RETURN
END
$ FORTY
$ INCODE IBMF

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SUBROUTINE CIRCJ(ISYM,NSJ,Y)
C   TO DEFINE THE UNIT NORMAL VECTOR TO THE SURFACE OF CIRCULAR JETS
DIMENSION Y(10,41)
PI=3.14159265
IF (ISYM .EQ. 0) GO TO 2014
NSJ1=NSJ+1
NN=(NSJ-1)/2+1
FN2=NN
NJH=NN+1
Y(1,1)=-SIN(PI/(2.*FN2))
Y(2,1)=-COS(PI/(2.*FN2))
GO TO 2013
2014 Y(1,1)=1.
Y(2,1)=0.
NSJ1=NSJ-1
FN2=NSJ/2
NJH=NSJ/2
2013 CONTINUE
DO 13 I=1,NSJ1
K=I
KI=I
IF (I .GT. NJH .AND. ISYM .NE. 0) K=I-NJH+1
IF (I .GT. NJH .AND. ISYM .EQ. 0) K=I-NJH
FI=K
IF (ISYM .NE. 0) ANG2=(FI-1.)*PI/FN2
IF (ISYM .EQ. 0) ANG2=FI*PI/FN2
YP=0.5*(1.-COS(ANG2))
IF (ISYM .EQ. 0) ANG2=FI-ATAN(SQRT(1.-YP*YP)/YP)
II=I+1
KK=I
KII=II
IF (I .GT. NJH) KK=II-NJH
FII=KK
IF (I .LE. NJH .AND. ISYM .EQ. 0) FII=KK+1
ANG1=(2.*FII-1.)*PI/(2.*FN2)
YP=0.5*(1.-COS(ANG1))
IF (ANG1 .GT. PI) YP=-YP
IF (ISYM .EQ. 0) ANG1=PI-ATAN(SQRT(1.-YP*YP)/YP)
IF (I .GT. NJH) GO TO 2015
GO TO 2016
2015 ANG1=-ANG1
ANG2=-ANG2
2016 CONTINUE
Y(1,KII)=SIN(ANG1)
Y(2,KII)=-COS(ANG1)
Y(3,KI)=SIN(ANG2)
Y(4,KI)=-COS(ANG2)
13 CONTINUE
RETURN
END
S   FORTY

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S      INCODE  IBMF
C      SUBROUTINE JSHAPE(XXL,XTT,YL,YJ,ZJ,RJ,CPCWL,IPANEL,NJ,JC,ISYM)
C      TO DEFINE THE LOCATIONS OF VORTEX AND CONTROL POINTS ON CIRCULAR
C      JETS
      DIMENSION CPCWL(1),XXL(1),XTT(1),YL(1)
      COMMON /CONST/ NCS,NCW,M1(8),NSJ,NCJ(5),LAST,MJW1(3,5),MJW2(3,5),J
1 PANEL,MJJ(5),NW(3),NNJ,NJP
      COMMON /GEOM/ HALFSW,XCP(200),YCP(200),ZCP(200),XLE(50),YLE(50),XT
1 E(50),PSI(20),CH(95),XV(200),YV(100),SN( 8,8),XN(200,2),YN(200,2),
2 ZN(200,2),WIDTH(8),YCON(25),SWEEP(50),HALFB,SJ(21,8),EX(95,2),TX(
3 95,2),SC(160,5),SI(160,5),LC(3)
      COMMON /SCHEME/ C(2),X(10,41),Y(10,41),SLOPE(15),XL(2,15),XTT(41),
1 XXL(41)
      PI=3.14159265
      N1=NSJ+1
      IF (ISYM .EQ. 0) N1=NSJ-1
      N2=N1+1
      IF (ISYM .EQ. 0) N2=NSJ
      N12=N1/2+2
      IF (ISYM .EQ. 0) N12=NSJ/2+1
      DO 1 I=1,2
      C(I)=XTT(I)-XXL(I)
      DO 1 J=1,NJ
1 XL(I,J)=XXL(I)+CPCWL(J)*C(I)
      DO 2 J=1,NJ
      FJ=J
      FNCJ=NJ
      PSI(J)=0.5*(1.-COS(FJ*PI/FNCJ))
2 SLOPE(J)=(XL(2,J)-XL(1,J))/(2.*RJ)
      DO 3 K=1,N2
      YY=Y(2,K)
      IF (ISYM .NE. 0 .AND. K .EQ. 1) YY=-1.
      IF (ISYM .NE. 0 .AND. K .EQ. 2) YY=-1.
      IF (K .EQ. (N12-1) .OR. K .EQ. N12) YY=1.
      IF (K .EQ. N2) YY=1.
      XTT(K)=YJ+RJ*YY
      DO 3 J=1,NJ
3 X(J,K)=XL(1,J)+SLOPE(J)*(XTT(K)-YL(1))
      DO 6 K=1,N1
      KK=JC+K
      L=K
      IF (K .EQ. N12) L=1
      EX(KK,1)=XXL(1)+(XXL(2)-XXL(1))*(XTT(L)-YL(1))/(2.*RJ)
      EX(KK,2)=XXL(1)+(XXL(2)-XXL(1))*(XTT(K+1)-YL(1))/(2.*RJ)
      TX(KK,1)=XTT(1)+(XTT(2)-XTT(1))*(XTT(L)-YL(1))/(2.*RJ)
      TX(KK,2)=XTT(1)+(XTT(2)-XTT(1))*(XTT(K+1)-YL(1))/(2.*RJ)


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      CH(KK)=C(1)-(C(1)-C(2))*0.5*(1.+Y(4,K))
      DO 6 J=1,NJ
      NPANEL=(K-1)*NJ+J-1+IPANEL
      DO 5 I=1,2
      KI1=K+I-1

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SIGN=1.
IF (K .EQ. N12 .AND. I .EQ. 1) KI1=1
IF (ISYM .EQ. 0) GO TO 21
IF (KI1 .EQ. 1 .OR. KI1 .EQ. 2) GO TO 20
GO TO 22
21 IF (K .EQ. N12 .AND. KI1 .EQ. 1) SIGN=-1.
22 CONTINUE
IF (KI1 .EQ. (N12-1) .OR. KI1 .EQ. N12) GO TO 25
IF (KI1 .EQ. N2) GO TO 25
YY=Y(2,KI1)
ZZ=Y(1,KI1)*SIGN
GO TO 30
20 YY=-1.
ZZ=-Y(1,KI1)/Y(2,KI1)
GO TO 30
25 YY=1.
ZZ=Y(1,KI1)/Y(2,KI1)
30 CONTINUE
XN(NPANEL,I)=X(J,KI1)
YN(NPANEL,I)=YJ+RJ*YY
5 ZN(NPANEL,I)=ZJ+RJ*ZZ
YK=0.5*(1.+Y(4,K))
IF (ISYM .EQ. 0) YK=2.*YK-1.
XCP(NPANEL)=XXL(1)+(XXL(2)-XXL(1))*YK+PSI(J)*CH(KK)
IF (ABS(YN(NPANEL,2)-YN(NPANEL,1)) .LE. 0.0001) GO TO 10
YCP(NPANEL)=YL(1)+YK*(YL(2)-YL(1))
ZCP(NPANEL)=ZN(NPANEL,1)+(ZN(NPANEL,2)-ZN(NPANEL,1))*(YCP(NPANEL)-
1 YN(NPANEL,1))/(YN(NPANEL,2)-YN(NPANEL,1))
GO TO 15
10 ZCP(NPANEL)=ZJ
YCP(NPANEL)=YN(NPANEL,1)
15 CONTINUE
XV(NPANEL)=XXL(1)+(XXL(2)-XXL(1))*YK+CPCWL(J)*CH(KK)
6 CONTINUE
JC=JC+N1
LAST=NPANEL
RETURN
END
$ LINK LINK22,LINK11
$ FORTY
$ LIMITS ,27K
$ INCODE IBMF
SUBROUTINE JETOFF
C TO SET UP THE JET OFF INFLUENCE COEFFICIENT MATRIX AND COMPUTE THE
C CAMBER TERMS
DIMENSION AW(101)
COMMON /AERO/ AM1,AM2,B1,B2,CL(30),CT(30),CD(30),GAM(2,100)
COMMON /ADD/ CP(100),CM(30),BREAK(8),SWP(8,15),GAL(30),ISYM,VMU,VU
1,TEMP,FCR,CAMLER,CAMLET,CAMTER,CAMTET,XJ,YJ,ZJ,RJ,ALP,CREF,TWISTR
COMMON /GEOM/ HALFSW,XCP(200),YCP(200),ZCP(200),XLE(50),YLE(50),XT
1E(50),PSI(20),CH(95),XV(200),YV(100),SN( 8,8),XN(200,2),YN(200,2),

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MG=NW(1)
IF (ABS(B1-B2) .LE. 0.001) GO TO 208
IF (IC .LE. 2) GO TO 209
208 CONTINUE
RETURN
END
S   FORTY
S   INCODE  ISMF
C   SUBROUTINE JETON(KCODE)
C   TO SET UP THE JET ON INFLUENCE COEFFICIENT MATRIX
    DIMENSION AW(300)
    COMMON /GEOM/ HALFSW,XCP(200),YCP(200),ZCP(200),XLE(50),YLE(50),XT
1E(50),PSI(20),CH(95),XV(200),YV(100),SN( 8,8),XN(200,2),YN(200,2),
2 ZN(200,2),WIDTH(8),YCCN(25),SWEEP(50),HALFB,SJ(21,8),EX(95,2),TX(
395,2),SC(160,5),SI(160,5),LC(3)
    COMMON /AERO/ AM1,AM2,B1,B2,CL(30),CT(30),CD(30),GAM(2,100)
    COMMON /CONST/ NCS,NCW,M1(8),NSJ,NCJ(5),LAST,MJW1(3,5),MJW2(3,5),J
1PANEL,MJJ(5),NW(3),NNJ,NJP
    COMMON /PARAM/ ALPT,ALPC,ALPS,CDF,SDF,TH,TDF
    COMMON /ADD/ CP(100),CM(30),BREAK(8),SWP(8,15),GAL(30),ISYM,VMU,VU
1,TEMP,FCR,CAMLER,CAMLET,CAMTER,CAMTET,XJ,YJ,ZJ,RJ,ALP,CREF,TWISTR
    COMMON /COST/ LTOTAL,LPAN1,NJW(5),LPANEL,IENTN,LPAN2,EXIT,PTIAL,TW
1IST,DF(5),NFP
    REWIND 03
    LP1=LTOTAL+1
    MJ=LPANEL+NCJ(1)
    MCON=LAST+NCJ(1)
    IPHI=1
    JL=LAST+1
    INN=1
    LN=1
    LN1=1
    JNN=1
    VMUC=VMU*ALPC
    MK=1
    I=LAST+1
    I1=I-JPANEL
    CALL MATRIX(AW,LTOTAL,LPANEL,VMUC,I,MCON,MJ,IPHI,INN,LN,LN1,TEMP,
1LPAN1,ISYM,KCODE,EXIT,LPAN2)
    WRITE (03) (AW(K),K=1,LTOTAL)
    KI=2
    NI=LTOTAL-1
    LI=LAST+2
    VMP=VMUC
310 KJ=LI
    IF (LI .GT. LAST) KJ=LI-JPANEL
301 CONTINUE
    CALL MATRIX(AW,LTOTAL,LPANEL,VMP,LI,MCON,MJ,IPHI,INN,LN,LN1,TEMP,
1LPAN1,ISYM,KCODE,EXIT,LPAN2)
    WRITE (03) (AW(K),K=1,LTOTAL)
350 IF (KJ .LT. MJ .OR. KJ .EQ. LAST) GO TO 351

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      IPHI=IPHI+1
      MJ=MJ+NCJ(INN)
351  CONTINUE
      MJI=MJJ(INN)-1
      IF (KJ .EQ. MJI) GO TO 312
      GO TO 313
312  JNN=INN
      INN=INN+1
313  IF (KJ .EQ. MJJ(JNN)) IPHI=1
      IF (LI .EQ. LTOTAL) GO TO 355
      GO TO 356
355  CONTINUE
      IPHI=1
      MJ=LPANEL+NCJ(1)
      JNN=1
      INN=1
356  CONTINUE
      KI=KI+1
      NI=NI-1
      IF (LI .EQ. LTOTAL) GO TO 361
      IF (LI .EQ. LAST) GO TO 364
      LI=LI+1
      GO TO 362
361  LI=LPANEL+1
      GO TO 362
364  LI=1
362  CONTINUE
      JP=LI-LAST+LPANEL
      JP1=JP-1
      IF (JP .EQ. MJJ(LN1)) LN1=LN1+1
      IF (JP1 .EQ. MJJ(LN)) LN=LN+1
      IF (KI .LE. LTOTAL) GO TO 310
      RETURN
      END

```

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$      FORTY
$      LIMITS ,31K
$      INCODE IBMF
      SUBROUTINE MATRIX(AW,LTOTAL,LPANEL,VMU,I,MCON,MJ,IPHI,INN,LN,LN1,T
1EMP,LPAN1,JSYM,KCODE,EXIT,LPAN2)
C      TO COMPUTE THE JET ON INFLUENCE COEFFICIENT MATRIX
      DIMENSION SV(300),W(4),AW(1)
      COMMON /AERO/ AM1,AM2,B1,B2,CL(30),CT(30),CD(30),GAM(2,100)
      COMMON /CONST/ NCS,NCW,M1(8),NSJ,NCJ(5),LAST,MJW1(3,5),MJW2(3,5),J
1PANEL,MJJ(5),NW(3),NNJ,NJP
      COMMON /GEOM/ HALFSW,XCP(200),YCP(200),ZCP(200),XLE(50),YLE(50),XT
1E(50),PSI(20),CH(95),XV(200),YV(100),SN( 8,8),XN(200,2),YN(200,2),
2 ZN(200,2),WIDTH(8),YCON(25),SWEEP(50),HALFB,SJ(21,8),EX(95,2),TX(
395,2),SC(160,5),SI(160,5),LC(3)
      COMMON /PARAM/ ALPT,ALPC,ALPS,COF,SDF,TH,TDF
      COMMON /SCHEME/ C(2),X(10,41),Y(10,41),SLOPE(15),XL(2,15),XTT(41),
1XLL(41)

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EQUIVALENCE (X(1,1),SV(1))
PI=3.14159265
ZJET=YCON(25)
IUSB=YCON(24)
DFJ=CDF
VUT=VMU
TEM=TEMP
NN2=NNJ-1
N1=NNJ-1
N2=NNJ-2
N3=NNJ-3
NJH=(NSJ+1)/2+1
IF (ISYM .EQ. 0) NJH=NSJ/2
IF (ISYM .EQ. 0) NP=NSJ-1
IF (ISYM .NE. 0) NP=NSJ+1
NJT=NJH-1
IZ=1
IFF=1
MM=NW(1)
NN=NW(1)
IND=1
ISN=1
L1=LPANEL+1
LAST1=LAST-1
IF (I .GT. LAST) GO TO 26
IJ=I
GO TO 27
26 IJ=I-JPANEL
27 CONTINUE
DO 16 J=1, LAST
MI=J-IFF+1
FN=NN
IF (J .GT. LPAN1 .AND. J .LE. LPAN2) ISN=2
IF (J .GT. LPAN2 .AND. J .LE. LPANEL) ISN=3
IF (J .GE. LPAN1 .AND. J .LT. LPANEL) GO TO 24
GO TO 25
24 NN=NW(2)
IF (J .GE. LPAN2 .AND. J .LT. LPANEL) NN=NW(3)
25 CONTINUE
IF (J .GE. LPANEL .AND. J .LT. MJJ(IND)) NN=NCJ(IND)
CHORD=CH(IZ)
IF (J .EQ. L1) GO TO 33
GO TO 34
33 ISN=ISN+1
L1=MJJ(IND)+1
34 NL=MJJ(IND)-1
IF (NL .EQ. LAST1) GO TO 90
IF (J .EQ. NL) IND=IND+1
90 CONTINUE
X1=XN(J,1)-XCP(IJ)
X2=XN(J,2)-XCP(IJ)

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X12=XN(J,2)-XN(J,1)
Y12=YN(J,2)-YN(J,1)
Z12=ZN(J,2)-ZN(J,1)
Z1=ZN(J,1)-ZCP(IJ)
Z2=ZN(J,2)-ZCP(IJ)
XZJ=X1*Z12-Z1*X12
DO 201 II=1,2
IF (II .EQ. 1) GO TO 2
N=1
GO TO 3
2 N=2
3 CONTINUE
YC=(-1.)*N*YCP(IJ)
Y1=YN(J,1)-YC
Y2=YN(J,2)-YC
XYK=X1*Y12-Y1*X12
YZI=Y1*Z12-Z1*Y12
ALB1=XYK*XYK+XZJ*XZJ+B1*YZI*YZI
R1B1=SQRT(X1*X1+B1*Y1*Y1+B1*Z1*Z1)
R2B1=SQRT(X2*X2+B1*Y2*Y2+B1*Z2*Z2)
UUB1=(X2*X12+B1*Y2*Y12+B1*Z2*Z12)/R2B1-(X1*X12+B1*Y1*Y12+B1*Z1*Z12
1)/R1B1
G1B1=(1.-X1/R1B1)/(Y1*Y1+Z1*Z1)
G2B1=(1.-X2/R2B1)/(Y2*Y2+Z2*Z2)
IF (I .GT. LPANEL) GO TO 20
F1=UUB1*XYK/ALB1
F2=-Y2*G2B1+Y1*G1B1
IF (J .GT. LPANEL) GO TO 110
GO TO 15
110 F3=0.
F4=0.
F1=2.*F1
F2=2.*F2
GO TO 15
20 CONTINUE
IF (J .LE. LPANEL) GO TO 117
IF (ABS(B1-B2) .LE. 0.001) GO TO 116
ALB2=XYK*XYK+XZJ*XZJ+B2*YZI*YZI
R1B2=SQRT(X1*X1+B2*Y1*Y1+B2*Z1*Z1)
R2B2=SQRT(X2*X2+B2*Y2*Y2+B2*Z2*Z2)
UUB2=(X2*X12+B2*Y2*Y12+B2*Z2*Z12)/R2B2-(X1*X12+B2*Y1*Y12+B2*Z1*Z12
1)/R1B2
G1B2=(1.-X1/R1B2)/(Y1*Y1+Z1*Z1)
G2B2=(1.-X2/R2B2)/(Y2*Y2+Z2*Z2)
GO TO 117
116 ALB2=ALB1
UUB2=UUB1
G2B2=G2B1
G1B2=G1B1
117 CONTINUE
IF (I .GT. LAST) GO TO 40

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F13=UUB1*XZJ/ALB1
F12=UUB1*XYK/ALB1
G13=Z2*G2B1-Z1*G1B1
G12=-Y2*G2B1+Y1*G1B1
IF (J .LE. LPANEL) GO TO 122
F23=UUB2*XZJ/ALB2
F22=UUB2*XYK/ALB2
G23=Z2*G2B2-Z1*G1B2
G22=-Y2*G2B2+Y1*G1B2
GO TO 125
122 F22=0.
    G22=0.
    F23=0.
    G23=0.
125 F1=-F13*Y(4,IPHI)*(-1.)*N+F12*Y(3,IPHI)
    F2=G13*Y(4,IPHI)*(-1.)*N+G12*Y(3,IPHI)
    F3=-F23*Y(4,IPHI)*(-1.)*N+F22*Y(3,IPHI)
    F4=G23*Y(4,IPHI)*(-1.)*N+G22*Y(3,IPHI)
    IF (J .LE. LPANEL) GO TO 17
    F1=F1*2.
    F2=2.*F2
    F4=2.*F4
    F3=2.*F3
    GO TO 17
40 F1=UUB1*YZI/ALB1
    IF (EXIT .LE. 0.001) GO TO 41
    IF (NNJ .EQ. 1) GO TO 41
    IF (IJ .GT. LPANEL .AND. IJ .LE. MJJ(1)) VMU=1.
    IF (IJ .GT. LPANEL .AND. IJ .LE. MJJ(1)) TEMP=1.
41 CONTINUE
    F2=0.
    IF (J .LE. LPANEL) GO TO 22
    F3=UUB2*YZI/ALB2
    F4=0.
    F3=-F3*2.
    F1=-F1*VMU*VMU*2.*TEMP
    GO TO 17
22 F1=-F1*VMU*VMU*TEMP
17 CONTINUE
15 W(I1)=(F1+F2)*CHORD*SN(MI,ISN)/(8.*FN)
    IF (J .LE. LPANEL) GO TO 200
    IF (I1 .EQ. 2) GO TO 200
    K2=I1+2
    W(K2)=(F3+F4)*CHORD*SN(MI,ISN)/(8.*FN)
200 CONTINUE
201 CONTINUE
    IF (J .LT. MM) GO TO 32
    IZ=IZ+1
    IFF=MM+1
    MM=MM+NN
32 CONTINUE

```

```

IF (J .LE. LPANEL) JA=J+2*JPANEL
IF (J .GT. LPANEL) JA=J-LPANEL+JPANEL
AW(JA)=W(1)+W(2)
SV(JA)=W(1)
IF (J .LE. LPANEL) GO TO 16
J1=J-LPANEL
AW(J1)=W(3)
VMU=VUT
TEMP=TEM
16 CONTINUE
IF (KCODE .EQ. 0) GO TO 28
IF (IUSB .EQ. 1 .AND. ZJET .GT. 0.01) GO TO 60
IF (DFJ .LE. 0.0001) GO TO 60
IF (NNJ .EQ. 1 .AND. I .LE. LPANEL) GO TO 60
IF (NNJ .EQ. 1 .AND. I .GT. LPANEL) GO TO 66
IF (I .LE. MJJ(N1) .OR. I .GT. LAST) GO TO 60
66 CONTINUE
IF (I .GT. LAST) GO TO 60
IF (IPHI .EQ. NJH) GO TO 60
IF (ISYM .NE. 0 .AND. IPHI .EQ. 1) GO TO 60
IF (IPHI .LT. NJH) IL=IPHI-ISYM
IF (IPHI .GT. NJH) IL=IPHI-NJH
REWIND (02)
IF (NNJ .EQ. 1) MJN1=LPANEL
IF (NNJ .NE. 1) MJN1=MJJ(N1)
MF=IJ-MJN1-(IPHI-1)*NCJ(NNJ)
FNNJ=NCJ(NNJ)
DISTJ=SDF
DLX=DISTJ*0.5*PI/FNNJ
SZX=-(1.-VMU)
IQ=(IL-1)*NCJ(NNJ)
CALL SKIP(IQ,JPANEL)
DO 61 JJ=1,MF
READ (02) (SV(K),K=1,JPANEL)
IF (JJ .EQ. MF) GO TO 65
DXTH=DLX*PSI(JJ)/TH
GO TO 67
65 DXTH=DLX*PSI(JJ)*0.5/TH
67 CONTINUE
PROD=SZX*DXTH
DO 62 K1=1,JPANEL
KK=K1+JPANEL
62 AW(KK)=AW(KK)+PROD*SV(K1)
61 CONTINUE
IQ=NCJ(NNJ)-MF+((NP-1-ISYM)/2-1)*NCJ(NNJ)
CALL SKIP(IQ,JPANEL)
DO 63 JJ=1,MF
READ (02) (SV(K),K=1,JPANEL)
IF (JJ .EQ. MF) GO TO 68
DXTH=DLX*PSI(JJ)/TH
GO TO 69

```

```

68 DXTH=DLX*PSI(JJ)*0.5/TH
69 PROD=SZX*DXTH
   DO 64 K1=1,JPANEL
     KK=K1+JPANEL
64  AW(KK)=AW(KK)-PROD*SV(K1)
63  CONTINUE
60  CONTINUE
   IF (EXIT .LE. 0.001) GO TO 29
   IF (NNJ .EQ. 1) GO TO 29
   IF (IJ .GT. LPANEL .AND. IJ .LE. MJJ(1)) VMU=1.
   IF (IJ .GT. LPANEL .AND. IJ .LE. MJJ(1)) TEMP=1.
29  CONTINUE
28  IF (I .LE. LAST) GO TO 70
   IF (IPHI .EQ. NJH) GO TO 300
   IF (ISYM .NE. 0 .AND. IPHI .EQ. 1) GO TO 300
   IF (NNJ .EQ. 1) GO TO 302
   IF (IJ .GT. MJJ(N1)) GO TO 302
   IF (IPHI .GT. NJH .AND. ZJET .LE. 0.01) GO TO 302
   IF (IPHI .GT. NJH) L1=NJH
   IF (ISYM .EQ. 0 .AND. IPHI .GT. NJH) L1=NJH+1
   IF (IPHI .LE. NJH) L1=1
   NZ=1
   IF (NW(2) .NE. 0 .AND. NW(3) .EQ. 0) NZ=2
   IF (NW(3) .NE. 0) NZ=3
   IF (NNJ .LE. 3 .AND. NW(2) .NE. 0) IR=N2
   IF (NNJ .LE. 3 .AND. NW(2) .EQ. 0) IR=N1
   IF (NNJ .GE. 4 .AND. NW(3) .NE. 0) IR=N3
   IF (NNJ .EQ. 4 .AND. NW(3) .EQ. 0) IR=N2
   DO 311 NR=1,NZ
     K1=MJW1(NR,NJP)+(IPHI-L1-ISYM)*NW(NR)-1
     K2=LC(NR)+IPHI-L1-ISYM
     KNW=NW(NR)
     K1=K1-KNW
     K2=K2-1
     MR=3
     IF (K1 .GE. 0) GO TO 400
     K1=K1+KNW
     K2=K2+1
     MR=2
400  DO 420 NQ=1,MR
     SUM=0.
     DO 310 KK=1,KNW
       KL=K1+KK
       JA=KL+2*JPANEL
310  SUM=SUM+SV(JA)
     CALL INTEG(RES,KNW,K1,K2,IJ,B1,IR)
     DO 315 KK=1,KNW
       KL=K1+KK
       JA=KL+2*JPANEL
       AA=1.
     DO 320 L=1,KNW

```

```

LL=K1+L
IF (L .EQ. KK) GO TO 320
AA=AA*(XCP(IJ)-XV(LL))/(XV(KL)-XV(LL))
320 CONTINUE
AW(JA)=AW(JA)-SUM*AA-RES*AA*VMU*VMU*TEMP
315 CONTINUE
K1=K1+KNW
K2=K2+1
420 CONTINUE
IR=IR+1
311 CONTINUE
302 CONTINUE
IF (KCODE .EQ. 0) GO TO 300
IF (NW(2) .EQ. 0) NSTRIP=NCS
IF (NW(2) .NE. 0 .AND. NW(3) .EQ. 0) NSTRIP=NCS*2
IF (NW(3) .NE. 0) NSTRIP=NCS*3
IF (IPHI .LT. NJH) IP=NJH+1
IF (IPHI .GT. NJH) IP=ISYM+1
IF (NNJ .EQ. 1) GO TO 325
IF (IJ .GT. MJJ(N1)) GO TO 325
IF (NNJ .EQ. 2) GO TO 330
IF (IJ .GT. MJJ(N2)) GO TO 330
IF (NNJ .EQ. 3) GO TO 381
IF (IJ .GT. MJJ(N3)) GO TO 383
IF (NNJ .EQ. 4) GO TO 385
IF (NNJ .EQ. 5 .AND. IJ .GT. MJJ(NNJ-4)) GO TO 386
L1=NNJ-4
IZ=NSTRIP
GO TO 335
386 L1=N3
IZ=NSTRIP+NP
GO TO 335
385 L1=N3
IZ=NSTRIP
GO TO 335
383 L1=N2
IZ=NSTRIP+(NNJ-3)*NP
GO TO 335
381 CONTINUE
L1=N2
IZ=NSTRIP
GO TO 335
325 L1=NNJ
IZ=NSTRIP+(NNJ-1)*NP
GO TO 335
330 L1=N1
IZ=NSTRIP+(NNJ-2)*NP
335 CONTINUE
IZ=IZ+IP
NT=NJT
IF (ISYM .NE. 0) NT=NJT-1

```

```

KNW=NCJ(L1)
DO 341 KP=1,NT
SUM1=0.
SUM2=0.
K1=MJJ(L1)-NP*NCJ(L1)+(KP-1)*NCJ(L1)+(IP-1)*NCJ(L1)
DO 340 KK=1,KNW
KL=K1+KK
KJ=KL+JPANEL
IA=KL-LPANEL+JPANEL
IB=KJ-LAST
SUM1=SUM1+SV(IA)
340 SUM2=SUM2+AW(IB)
CALL INTEG(RES,KNW,K1,IZ,IJ,B1,L1)
IF (ABS(B1-B2) .LE. 0.001) GO TO 350
CALL INTEG (REF,KNW,K1,IZ,IJ,B2,L1)
GO TO 355
350 REF=RES
355 DO 360 KK=1,KNW
KL=K1+KK
KJ=KL+JPANEL
IA=KL-LPANEL+JPANEL
IB=KJ-LAST
AA=1.
DO 365 L=1,KNW
LL=K1+L
IF (L .EQ. KK) GO TO 365
AA=AA*(XCP(IJ)-XV(LL))/(XV(KL)-XV(LL))
365 CONTINUE
AW(IA)=AW(IA)-SUM1*AA-RES*AA*VMU*VMU*TEMP*2.
AW(IB)=AW(IB)-SUM2*AA-REF*AA*2.
360 CONTINUE
342 IZ=IZ+1
341 CONTINUE
300 CONTINUE
SK=1.
IF (IPHI .GT. NJH) SK=-1.
JI=I-LAST+LPANEL
K=MCON-LAST-NCJ(LN)+LPANEL
JNJ=NCJ(LN)
DO 52 KK=1,JNJ
KL=K+KK
KJ=KL+JPANEL
IA=KL-LPANEL+JPANEL
IB=KJ-LAST
AA=1.
DO 53 L=1,JNJ
LL=K+L
IF (L .EQ. KK) GO TO 53
AA=AA*(XCP(JI)-XV(LL))/(XV(KL)-XV(LL))
53 CONTINUE
AW(IB)=AW(IB)+AA*SK

```

```

52  AW(IA)=AW(IA)-AA*VMU*VMU*TEMP*SK
    IF (I .EQ. MCON .AND. I .LT. LTOTAL) MCON=MCON+NCJ(LN1)
    IF (KCODE .EQ. 0) GO TO 71
    IF (IUSB .EQ. 1 .AND. ZJET .GT. 0.01) GO TO 71
    IF (NNJ .EQ. 1) GO TO 71
    IF (IJ .GT. MJJ(N1)) GO TO 71
    IF (IPHI .LE. NJH) GO TO 71
    L1=NJH
    IF (ISYM .EQ. 0) L1=NJH+1
    IF (NW(2) .EQ. 0) GO TO 170
    IF (NW(3) .EQ. 0) GO TO 171
    IF (IJ .GT. MJJ(N2)) GO TO 82
    IF (IJ .GT. MJJ(N3)) GO TO 72
    IF (NNJ .EQ. 4) GO TO 77
    IF (NNJ .EQ. 5 .AND. IJ .GT. MJJ(NNJ-4)) GO TO 77
    GO TO 71
171 IF (IJ .GT. MJJ(N2)) GO TO 72
    IF (NNJ .EQ. 3) GO TO 77
    IF (NNJ .EQ. 4 .AND. IJ .GT. MJJ(N3)) GO TO 77
    GO TO 71
170 IF (NNJ .EQ. 2) GO TO 77
    IF (NNJ .EQ. 3 .AND. IJ .GT. MJJ(N2)) GO TO 77
    GO TO 71
77  K1=MJW1(1,NJP)+(IPHI-L1-ISYM)*NW(1)-1
    KNW=NW(1)
    GO TO 73
72  K1=MJW1(2,NJP)+(IPHI-L1-ISYM)*NW(2)-1
    KNW=NW(2)
    GO TO 73
82  K1=MJW1(3,NJP)+(IPHI-L1-ISYM)*NW(3)-1
    KNW=NW(3)
73  DO 74 KK=1,KNW
    KL=K1+KK
    JA=KL+2*JPANEL
    AA=1.
    DO 75 L=1,KNW
    LL=K1+L
    IF (L .EQ. KK) GO TO 75
    AA=AA*(XCP(IJ)-XV(LL))/(XV(KL)-XV(LL))
75  CONTINUE
74  AW(JA)=AW(JA)-AA*VMU*VMU*TEMP*0.5
71  CONTINUE
    IF (KCODE .EQ. 0) GO TO 70
    IF (ZJET .GT. 0.01) GO TO 70
    IF (DFJ .LE. 0.0001) GO TO 70
    IF (NNJ .EQ. 1) GO TO 76
    IF (IJ .LE. MJJ(N1)) GO TO 70
76  CONTINUE
    IF (IPHI .EQ. NJH) GO TO 70
    IF (ISYM .NE. 0 .AND. IPHI .EQ. 1) GO TO 70
    DO 79 J=1,JPANEL

```

```

JJ=J+JPANEL
79 SV(J)=-AW(JJ)
WRITE (02) (SV(J),J=1,JPANEL)
70 CONTINUE
VMU=VUT
TEMP=TEM
101 FORMAT (10(F11.5))
100 FORMAT (6(5X,I3))
RETURN
END

```

```

$ FORTY
$ INCODE IBMF
SUBROUTINE SKIP (I,JPANEL)
DIMENSION DUMMY(200)
IF (I .EQ. 0) GO TO 1
DO 2 J=1,I
READ (02) (DUMMY(K),K=1,JPANEL)
2 CONTINUE
1 RETURN
END

```

```

$ FORTY
$ INCODE IBMF
SUBROUTINE WING (AW,LPANEL,I,BB,LPAN1,LPAN2)
C TO COMPUTE THE JET OFF INFLUENCE COEFFICIENT MATRIX
DIMENSION AW(1),W(2)
COMMON /AERO/ AM1,AM2,B1,B2,CL(30),CT(30),CD(30),GAM(2,100)
COMMON /GEOM/ HALFSW,XCP(200),YCP(200),ZCP(200),XLE(50),YLE(50),XT
1E(50),PSI(20),CH(95),XV(200),YV(100),SN( 8,8),XN(200,2),YN(200,2),
2 ZN(200,2),WIDTH(8),YCON(25),SWEEP(50),HALFB,SJ(21,8),EX(95,2),TX(
395,2),SC(160,5),SI(160,5),LC(3)
COMMON /CONST/ NCS,NCW,M1(8),NSJ,NCJ(5),LAST,MJW1(3,5),MJW2(3,5),J
1PANEL,MJJ(5),NW(3),NNJ,NJP
IZ=1
IFF=1
ISN=1
NL=NW(1)
NN=NW(1)
DO 16 J=1,LPANEL
MI=J-IFF+1
FN=NL
IF (J .GT. LPAN1 .AND. J .LE. LPAN2) ISN=2
IF (J .GT. LPAN2 .AND. J .LE. LPANEL) ISN=3
IF (J .GE. LPAN1 .AND. J .LT. LPANEL) GO TO 20
GO TO 21
20 NL=NW(2)
IF (J .GE. LPAN2 .AND. J .LT. LPANEL) NL=NW(3)
21 CONTINUE
X1=XN(J,1)-XCP(I)
X2=XN(J,2)-XCP(I)
X12=XN(J,2)-XN(J,1)
Y12=YN(J,2)-YN(J,1)

```



```

DO 15 II=1,2
IF (II.EQ.1) GO TO 2
N=1
GO TO 3
2 N=2
3 CONTINUE
YC=(-1.)*N*YCP(I)
Y1=YN(J,1)-YC
Y2=YN(J,2)-YC
XYK=X1*Y12-Y1*X12
R1=SQRT(X1*X1+BB*Y1*Y1)
R2=SQRT(X2*X2+BB*Y2*Y2)
U1=(X12*X2+BB*Y12*Y2)/R2-(X12*X1+BB*Y12*Y1)/R1
U1=U1/XYK
U2=(1.-X1/R1)/Y1
U3=(1.-X2/R2)/Y2
15 W(II)=(U1+U2-U3)*CH(IZ)*SN(MI,ISN)/(8.*FN)
AW(J)=W(1)+W(2)
IF (J.LT.NN.OR.J.EQ.LPANEL) GO TO 16
IZ=IZ+1
IFF=NN+1
NN=NN+NL
16 CONTINUE
RETURN
END

```

```

$ LINK LINK33,LINK22
$ FORTY
$ INCODE IBMF

```

SUBROUTINE WALNOL

```

C THIS PROGRAM DETERMINE THE OPTIMUM CAMBER SHAPE AND TWIST
C DISTRIBUTION WITH SPECIFIED LIFT AND PITCHING MOMENT CONSTRAINTS
C IN THE WING-ALONE CASE WITH ZERO LEADING EDGE SUCTION.
PARAMETER IPANEL=60,ICW=6
PARAMETER LLO=IPANEL**2,LL1=(IPANEL+3)**2/4+1
EQUIVALENCE (BIGCX(1,1),AIJ(1,1),FNWW(1,1))
DIMENSION CDGW(IPANEL),CLGW(IPANEL),CMGW(IPANEL)
DIMENSION AW(200),CA(200),CDII(20),PAMBDA(2),BA(200)
DIMENSION GAMMA(LL1),BCNDN(ICW),VKSTD(IPANEL),THETA1(ICW)
DIMENSION AA(10),FNWW(IPANEL,IPANEL),BIGCX(IPANEL,IPANEL)
DIMENSION AK(IPANEL),CONST(IPANEL),CAMZC(IPANEL)
DIMENSION DNWW(ICW,IPANEL),CX(ICW,ICW),AIJ(IPANEL,IPANEL)
COMMON /AERO/ AM1,AM2,B1,B2,CL(30),CT(30),CD(30),GAM(2,100)
COMMON /PARAM/ ALPT,ALFC,ALPS,CDF,SDF,TH,TDF
COMMON /CLOPE/ DZDXK(100),ALPA0(15),GCB(100),GCBX(100),THETAK(10)
1,CCX(100),OZDXK(100),GAN(2,100)
COMMON /ADD/ CP(100),CM(30),BREAK(8),SWP(8,15),GAL(30),ISYM,VMU,VU
1,TEMP,FCR,CAMLER,CAMLET,CAMTER,CAMTET,XJ,YJ,ZJ,RJ,ALP,CREF,TWISTR
COMMON /CONST/ NCS,NCW,M1(8),NSJ,NCJ(5),LAST,MJW1(3,5),MJW2(3,5),J
1PANEL,MJJ(5),NW(3),NNJ,NJP
COMMON /COST/ LTOTAL,LPAN1,NJW(5),LPANEL,IENTN,LPAN2,EXIT,PTIAL,TW
1IST,DF(5),NFP

```

```
COMMON /GEOM/ HALFSW,XCP(200),YCP(200),ZCP(200),XLE(50),YLE(50),XT
1E(50),PSI(20),CH(95),XV(200),YV(100),SN( 8,8),XN(200,2),YN(200,2),
2 ZN(200,2),WIDTH(8),YCCN(25),SWEEP(50),HALFB,SJ(21,8),EX(95,2),TX(
395,2),SC(160,5),SI(160,5),LC(3)
```

```
COMMON /IDENT/ DZDXK1(100),GAM1(100),CAMZC1(100),ALPA01(20),YLE1(2
10)
```

```
13. FORMAT (4F10.5,I10)
```

```
14. FORMAT (1H,'CDBAR,CLBAR,CMBAR,DELTA,MAXP')
```

```
CALL INVRXC (THETAI,BONDN,AA,IPANEL,BIGCX,AK,ICW,CX)
```

```
CALL WALNO2 (AIJ,AW,FNWW,IPANEL,BA,DNWW,ICW,CX)
```

C

C ***THEORETICAL MINIMUM INDUCED DRAG COEFFICIENT,LIFT CONSTRAINT,
C PITCHING MOMENT CONSTRAINT,INITIAL STEP SIZE,MAXIMUM NUMBER OF
C ITERATIONS ***

```
WRITE (6,14)
```

```
READ (5,13) CDBAR,CLBAR,CMBAR,DELTA ,MAXP
```

```
WRITE (6,13) CDBAR,CLBAR,CMBAR,DELTA,MAXP
```

C

```
DO 91 J=1,LPANEL
```

```
GAMMA(J)=0.0
```

```
91. CONTINUE
```

```
N=0
```

C

```
38. N=N+1
```

```
WRITE (6,200) DELTA,N
```

```
200. FORMAT (1H,'THE COMPUTED STEP SIZE, DELTA=',F10.3,5X,'AT',I3,'TH
1. ITERATION')
```

```
DO 31 I=1,LPANEL
```

```
GAM(1,I)=GAMMA(I)
```

```
GAM(2,I)=GAMMA(I)
```

```
31. CONTINUE
```

```
CALL WALNO3 (GAMMA,DELTA,AW,CA,CDII,CLBAR,CMBAR,PAMBDA,N,IPANEL,
1,AIJ)
```

```
IF (N.EQ.1) GO TO 79
```

```
IF (CDII(N).LT.CDBAR) GO TO 29
```

```
IF (ABS((CDII(N)-CDBAR)/CDBAR) .LT. 0.05) GO TO 60
```

```
IF (CDII(N) .GT. CDII(N-1)) GO TO 39
```

```
GO TO 79
```

```
29. CDII(N)=CDII(N-1)
```

```
39. CONTINUE
```

```
DELTA=0.5*DELTA
```

```
DO 49 I=1,LPANEL
```

```
GAMMA(I)=GAM(1,I)
```

```
GAMMA(I)=GAM(2,I)
```

```
49. CONTINUE
```

```
GO TO 68
```

```
79. CONTINUE
```

```
CALL WALNO4 (GAMMA,DELTA ,PAMBDA,CA,VKSTD,CDGW,CLGW,CMGW,IPANEL
1,AIJ)
```

```
68. CONTINUE
```

```
IF (N.LT.MAXP) GO TO 38
```

```

C
60  CONTINUE
    DO 81 I=1,LPANEL
        GAM(1,I)=GAMMA(I)
        GAM(2,I)=GAMMA(I)
81  CONTINUE
    CALL WALNO5 (AK,CAMZC,CONST,GAMMA,BA)
    DO 71 I=1,LPANEL
        CP(I)=2.*GAMMA(I)*ALPC
71  CONTINUE
    WRITE (6,9)
9   FORMAT (1H,'OPTIMUM PRESSURE LOADING IN THE WING ALONE CASE')
    WRITE (6,8) (CP(I),I=1,LPANEL)
8   FORMAT (1H,'6F10.5')
    RETURN
    END
$   FORTY
$   INCODE  IBMF
SUBROUTINE WALNO2 (AIJ,AW,FNWW,IPANEL,BA,DNWW,ICW,CX)
C   SET UP THE TRANSFORMATION MATRIX 'A(I,J)'
    DIMENSION AIJ(IPANEL,1),AW(1),FNWW(IPANEL,1),BA(1),DNWW(ICW,1)
    DIMENSION CX(ICW,1)
    COMMON /CLOPE/ DZDXK(100),ALPA0(15),GCB(100),GCBX(100),THETAK(10)
1   ,CCX(100),OZDXK(100),GAN(2,100)
    COMMON /CONST/ NCS,NCW,M1(8),NSJ,NCJ(5),LAST,MJW1(3,5),MJW2(3,5),J
1   PANEL,MJJ(5),NW(3),NNJ,NJP
    COMMON /COST/ LTOTAL,LPAN1,NJW(5),LPANEL,IENTN,LPAN2,EXIT,PTIAL,TW
1   IST,DF(5),NFP
    L1=LPANEL+1
    IF (NW(2).EQ.0) GO TO 5
    REWIND 01
    DO 1 I=1,LPANEL
        READ (01) (AW(K),K=1,L1)
    DO 1 J=1,LPANEL
        FNWW(I,J)=AW(J)
1   CONTINUE
    REWIND 08
    DO 2 I=1,LPANEL
        WRITE (03) (FNWW(J,I),J=1,LPANEL)
2   CONTINUE
    REWIND 04
    DO 3 I=1,LPANEL
        REWIND 08
        READ (04) (AW(L),L=1,LPANEL)
        DO 4 J=1,LPANEL
            AIJ(I,J)=0.0
        READ (08) (BA(L),L=1,LPANEL)
        DO 4 K=1,LPANEL
4       AIJ(I,J)=AIJ(I,J)+AW(K)*BA(K)
3   CONTINUE
    GO TO 10

```

```

5  CONTINUE
   REWIND 01
   DO 16 I=1,NCS
   DO 17 M=1,NCW
   READ (01) (AW(K),K=1,L1)
   DO 18 N=1,LPANEL
18  DNWW(M,N)=AW(N)
17  CONTINUE
   DO 6 IK=1,NCW
   DO 6 JJ=1,LPANEL
   II=(I-1)*NCW+IK
   AIJ(II,JJ)=0.0
   DO 7 L=1,NCW
7   AIJ(II,JJ)=AIJ(II,JJ)+CX(IK,L)*DNWW(L,JJ)
   6  CONTINUE
16  CONTINUE
10  CONTINUE
   RETURN
   END

$   FORTY
$   INCODE  IBMF
   SUBROUTINE WALN03 (GAMMA,DELTA,AW,CA,CDII,CLBAR,CMBAR,PAMBDA,N,
1  IPANEL,AIJ)
C   FIND THE WING ALONE VORTEX STRENGTH AT THE N-TH ITERATION
   DIMENSION AW(1),CA(1),GAMMA(1),CDII(1),PAMBDA(1),AIJ(IPANEL,1)
   COMMON /AERO/ AM1,AM2,B1,B2,CL(30),CT(30),CD(30),GAM(2,100)
   COMMON /CLOPE/ DZDXK(100),ALPA0(15),GCB(100),GCBX(100),THETA(10)
1  ,CCX(100),OZDXK(100),GAN(2,100)
   COMMON /CONST/ NCS,NCW,M1(8),NSJ,NCJ(5),LAST,MJW1(3,5),MJW2(3,5),J
1  PANEL,MJJ(5),NW(3),NNJ,NJP
   COMMON /GEOM/ HALFSW,XCP(200),YCP(200),ZCP(200),XLE(50),YLE(50),XT
1  E(50),PSI(20),CH(95),XV(200),YV(100),SN( 8,8),XN(200,2),YN(200,2),
2  ZN(200,2),WIDTH(8),YCCN(25),SWEEP(50),HALFB,SJ(21,8),EX(95,2),TX(
3  95,2),SC(160,5),SI(160,5),LC(3)
   COMMON /COST/ LTOTAL,LPAN1,NJW(5),LPANEL,IENTN,LPAN2,EXIT,PTIAL,TW
1  IST,DF(5),NFP
   PI=3.14159265
   L1=LPANEL+1
   L2=LPANEL+2
   L3=LPANEL+3
   REWIND 08
   DO 71 I=1,LPANEL
   DO 72 J=1,LPANEL
   IF (J .EQ. I) GO TO 73
   CA(J)=0.0
   GO TO 72
73  CA(J)=1.0
72  CONTINUE
   CA(L1)=PI**2*GCB(I)/(HALFSW*2.)*DELTA
   CA(L2)=PI**2*GCBX(I)/(HALFSW*2.)*DELTA
   ADGW=0.

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DO 74 K=1,LPANEL
ADGW =ADGW -(GCB(I)*AIJ(I,K)+GCB(K)*AIJ(K,I))*GAM(1,K)
74 CONTINUE
CA(L3)=ADGW *PI**2*DELTA/(HALFSW*2.)
WRITE (08) (CA(KK),KK=1,L3)
71 CONTINUE
DO 75 K=1,LPANEL
CA(K)=GCB(K)*PI*PI/(HALFSW*2.)
75 CONTINUE
CA(L1)=0.0
CA(L2)=0.0
CA(L3)=CLII-CLBAR
WRITE (08) (CA(J),J=1,L3)
DO 76 L=1,LPANEL
CA(L)=GCBX(L)*PI*PI/(HALFSW*2.)
76 CONTINUE
CA(L1)=0.0
CA(L2)=0.0
CA(L3)=CMII-CMBAR
WRITE (08) (CA(J),J=1,L3)
C
REWIND 08
READ (08) (AW(I),I=1,L3)
DO 77 I=1,L2
GAMMA(I)=-AW(I+1)/AW(1)
77 CONTINUE
NJ=L2-1
DO 78 IJ=2,L2
READ (08) (AW(I),I=1,L3)
IK=IJ
CALL VMSEQN (NJ,IK,AW,GAMMA,CA)
NJ=NJ-1
78 CONTINUE
PAMBDA(1)=GAMMA(L1)
PAMBDA(2)=GAMMA(L2)
DO 36 I=1,LPANEL
GAMMA(I)=GAM(1,I)+GAMMA(I)
36 CONTINUE
DO 21 I=1,LPANEL
DZDXK(I)=0.0
DO 22 J=1,LPANEL
DZDXK(I)=DZDXK(I)+AIJ(I,J)*GAMMA(J)
22 CONTINUE
21 CONTINUE
CLII=0.0
CMII=0.0
CDII(N)=0.0
DO 50 I=1,LPANEL
CDII(N)=CDII(N)+GCB(I)*DZDXK(I)*GAMMA(I)
CLII=CLII+GCB(I)*GAMMA(I)
CMII=CMII+GCBX(I)*GAMMA(I)

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50  CONTINUE
    CDII(N)=-PI**2*CDII(N)/(HALFSW*2.)
    CLII=PI*PI*CLII/(HALFSW*2.)
    CMII=PI*PI*CMII/(HALFSW*2.)
    WRITE (6,134) CDII(N)
134  FORMAT (1H,'INDUCED DRAG COEFFICIENT',    CDII=' ',F15.5)
    WRITE (6,135) CLII
135  FORMAT (1H,'LIFT COEFFICIENT',            CLII=' ',F15.5)
    WRITE (6,136) CMII
136  FORMAT (1H,'PITCHING MOMENT COEFFICIENT,CMII=' ',F15.5)
    RETURN
    END

$    FORTY
$    INCODE  IBMF
    SUBROUTINE WALN04 (GAMMA,DELTA ,PAMBDA,CA,VKSTD,CDGW,CLGW,CMGW,
1  IPANEL,AIJ)
C    CALCULATE THE STEP SIZE BY ONE DIMENSIONAL OPTIMIZATION
C    TECHNIQUE
    DIMENSION CA(1),VKSTD(1),CDGW(1),CLGW(1),CMGW(1),GAMMA(1)
    DIMENSION PAMBDA(1),AIJ(IPANEL,1)
    COMMON /CLOPE/ DZDXK(100),ALPA0(15),GCB(100),GCBX(100),THETAK(10)
1  ,CCX(100),DZDXK(100),GAN(2,100)
    COMMON /GEOM/ HALFSW,XCP(200),YCP(200),ZCP(200),XLE(50),YLE(50),XT
1  E(50),PSI(20),CH(95),XV(200),YV(100),SN( 8,8),XN(200,2),YN(200,2),
2  ZN(200,2),WIDTH(8),YCCN(25),SWEEP(50),HALFB,SJ(21,8),EX(95,2),TX(
3  95,2),SC(160,5),SI(160,5),LC(3)
    COMMON /COST/ LTOTAL,LPAN1,NJW(5),LPANEL,IENTN,LPAN2,EXIT,PTIAL,TW
1  IST,DF(5),NFP
    PI=3.14159265
    DO 12 I=1,LPANEL
        CA(I)=0.0
    DO 13 J=1,LPANEL
        CA(I)=CA(I)+(GCB(I)*AIJ(I,J)+GCB(J)*AIJ(J,I))*GAMMA(J)
13  CONTINUE
        CDGW(I)=-PI*PI*CA(I)/(HALFSW*2.)
12  CONTINUE
        DO 15 I=1,LPANEL
            CLGW(I)=PI*PI*GCB(I)/(HALFSW*2.)
15  CONTINUE
            DO 16 I=1,LPANEL
                CMGW(I)=PI*PI*GCBX(I)/(HALFSW*2.)
16  CONTINUE
            DO 90 I=1,LPANEL
                VKSTD(I)=0.0
                VKSTD(I)=VKSTD(I)-(CDGW(I)+PAMBDA(1)*CLGW(I)+PAMBDA(2)*CMGW(I))
90  CONTINUE
                CDGW1=0.0
                CDGW2=0.0
                DO 92 J=1,LPANEL
                    DDGW=0.0
                DO 93 I=1,LPANEL

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DDGW=DDGW+(GCB(I)*AIJ(I,J)+GCB(J)*AIJ(J,I))*VKSTD(I)
93 CONTINUE
CDGW1=CDGW1+DDGW*GAMMA(J)
CDGW2=CDGW2+DDGW*VKSTD(J)
92 CONTINUE
BOR=CDGW1
DOR=CDGW2
DELTA=ABS(BOR/DOR)
RETURN
END
$ FORTY
$ INCODE IBMF
SUBROUTINE WALN05 (AK,CAMZC,CONST,GAMMA,BA)
C FIND THE CAMBER ORDINATES AND LOCAL ANGLE OF ATTACK
DIMENSION ALPA(15)
DIMENSION AK(1),CAMZC(1),CONST(1),GAMMA(1),BA(1)
COMMON /CLOPE/ DZDXK(100),ALPA0(15),GCB(100),GCBX(100),THETAK(10)
1,CCX(100),OZDXK(100),GAN(2,100)
COMMON /CONST/ NCS,NCW,M1(8),NSJ,NCJ(5),LAST,MJW1(3,5),MJW2(3,5),J
1PANEL,MJJ(5),NW(3),NNJ,NJP
COMMON /COST/ LTOTAL,LPAN1,NJW(5),LPANEL,IENTN,LPAN2,EXIT,PTIAL,TW
1IST,DF(5),NFP
COMMON /GEOM/ HALFSW,XCP(200),YCP(200),ZCP(200),XLE(50),YLE(50),XT
1E(50),PSI(20),CH(95),XV(200),YV(100),SN( 8,8),XN(200,2),YN(200,2),
2 ZN(200,2),WIDTH(8),YCON(25),SWEEP(50),HALFB,SJ(21,8),EX(95,2),TX(
395,2),SC(160,5),SI(160,5),LC(3)
COMMON /IDENT/ DZDXK1(100),GAM1(100),CAMZC1(100),ALPA01(20),YLE1(2
10)
PI=3.14159265
NW2=NW(1)+NW(2)
IF (NW(2) .EQ. 0) GO TO 48
II=NCS+1
IF (NW(3) .NE. 0) GO TO 50
CHORD=CH(1)+CH(II)
XX1=CH(1)/CHORD
THETA1=ARCOS(1.-2.*XX1)
THETA2=PI
GO TO 51
50 III=II+NCS
CHORD=CH(1)+CH(II)+CH(III)
XX1=CH(1)/CHORD
THETA1=ARCOS(1.-2.*XX1)
XX2=(CH(1)+CH(II))/CHORD
THETA2=ARCOS(1.-2.*XX2)
51 CONTINUE
GO TO 49
48 THETA1=PI
49 CONTINUE
WRITE (6,102)
102 FORMAT (1H , 'THE TWIST DISTRIBUTION IN THE SPANWISE DIRECTION')
K1=1

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K2=2
DO 23 KI=1, NCS
DO 25 N=1, NCW
NA=(KI-1)*NCW+N
AK(NA)=0.0
FN=N-1
DO 27 L=1, NCW
IF (L.LE.NW(1)) KB=(KI-1)*NW(1)+L
IF (L.GT.NW(1) .AND. L.LE.NW2) KB=LPAN1+(KI-1)*NW(2)+L-NW(1)
IF (L.GT.NW2) KB=LPAN2+(KI-1)*NW(3)+L-NW2
IF (L.LE.NW(1)) GO TO 100
IF (L.GT.NW(1) .AND. L.LE.NW2) GO TO 200
IF (L.GT.NW2) GO TO 300
100 FNW=NW(1)
THETA=THETA1
GO TO 400
200 FNW=NW(2)
THETA=THETA2-THETA1
GO TO 400
300 FNW=NW(3)
THETA=PI-THETA2
400 CONTINUE
AK(NA)=AK(NA)+THETA*DZDXK(KB)*COS(FN*THETAK(L))/(FNW*PI)
27 CONTINUE
IF (N.GT.1) AK(NA)=2.*AK(NA)
25 CCNTINUE
CONST1=0.0
CONST2=0.0
DO 88 J=3, NCW
GK=J-1
KG=(KI-1)*NCW+J
CONST1=CONST1+0.25*AK(KG)*(1./(1.-GK)+1./(1.+GK))
CONST2=CONST2+0.25*AK(KG)*(1./(1.-GK)*COS((1.-GK)*PI)+1./(1.+GK)*C
10S((1.+GK)*PI))
88 CONTINUE
CONST3=0.125*AK(K2)
CONST(KI)=CONST1+CONST3
ALPAO(KI)=CONST2-CONST1-AK(K1)
ALPA(KI)=ALPAO(KI)*180./PI
DO 29 M=1, NCW
MM=(KI-1)*NCW+M
CAMZC(MM)=0.0
DO 30 K=3, NCW
FK=K-1
KD=(KI-1)*NCW+K
CAMZC(MM)=CAMZC(MM)-0.25*AK(KD)*(1./(1.-FK)*COS((1.-FK)*THETAK(M))
1+1./(1.+FK)*COS((1.+FK)*THETAK(M)))
30 CONTINUE
CONST4=-CONST3*COS(2.*THETAK(M))
CAMZC(MM)=CAMZC(MM)+(ALPAO(KI)+AK(K1))*0.5*(1.-COS(THETAK(M)))+CON
1ST4+CONST(KI)

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29  CONTINUE
    K1=K1+NCW
    K2=K2+NCW
    WRITE (6,126) KI,YLE(KI),KI,ALPA(KI)
126  FORMAT (1H , 'YLE(',I2,')=',F15.5,5X,'ALPAO(',I2,')=',F15.5)
23  CONTINUE
    WRITE (6,129)
129  FORMAT (1H , 'THE CAMBER ORDINATES IN THE WING ALONE CASE')
    WRITE (6,127) (CAMZC(JJ),JJ=1,LPANEL)
127  FORMAT (1H ,6F10.5)
    DO 60 I=1,NCS
        YLE1(I)=YLE(I)
        ALPA01(I)=ALPA0(I)
60  CONTINUE
    DO 65 J=1,LPANEL
        CAMZC1(J)=CAMZC(J)
        DZDXK1(J)=DZDXK(J)
        GAM1(J)=GAMMA(J)
65  CONTINUE
    RETURN
    END

$    LINK    LINK44,LINK33
$    FORTY
$    INCODE  IBMF/
    SUBROUTINE INVMTX
C    INVERT THE AUGMENTED MATRIX OF THE BOUNDARY CONDITIONS
    PARAMETER JPANEE=80,IPANEL=60
    PARAMETER ITOTAL=2*JPANEE+IPANEL
    DIMENSION BIGTRX(ITOTAL,ITOTAL),CONDN(ITOTAL),AW(300)
    COMMON /COST/ LTOTAL,LPAN1,NJW(5),LPANEL,IENTN,LPAN2,EXIT,PTIAL,TW
    1IST,DF(5),NFP
    COMMON /CONST/ NCS,NCW,M1(8),NSJ,NCJ(5),LAST,MJW1(3,5),MJW2(3,5),J
    1PANEL,MJJ(5),NW(3),NNJ,NJP
    CALL JETNO3 (ITOTAL,AW,CONDN,BIGTRX)
    RETURN
    END

$    FORTY
$    INCODE  IBMF
    SUBROUTINE JETNO3 (ITOTAL,AW,CONDN,BIGTRX)
C    INVERT THE AUGMENTED MATRIX BY H.E.M.P. SUBROUTINE
    DIMENSION AW(1),CONDN(1),BIGTRX(ITOTAL,1)
    COMMON /COST/ LTOTAL,LPAN1,NJW(5),LPANEL,IENTN,LPAN2,EXIT,PTIAL,TW
    1IST,DF(5),NFP
    COMMON /CONST/ NCS,NCW,M1(8),NSJ,NCJ(5),LAST,MJW1(3,5),MJW2(3,5),J
    1PANEL,MJJ(5),NW(3),NNJ,NJP
    REWIND 03
    DO 5 I=1,LTOTAL
        READ (03) (AW(K),K=1,LTOTAL)
        DO 6 J=1,LTOTAL
            BIGTRX(I,J)=AW(J)
6    CONTINUE

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5  CONTINUE
   LTO=LTOTAL
   CALL SETDIM (BIGTRX,LTO,LTO)
   CALL HEMINV (BIGTRX,LTO,CONDN)
   REWIND 09
   DO 9 I=1,LTOTAL
   WRITE (09) (BIGTRX(I,J),J=1,LTOTAL)
9  CCNTINUE
   RETURN
   END
$   LINK    LINK55,LINK44
$   FORTY
$   INCODE  IBMF
SUBROUTINE COMJET (KCODE)
C  FIND ALL MATRICES ARE NEEDED AND STORE THOSE MATRICES ON FILES
   PARAMETER IPANEL=60,ICW=6,JPANEE=80
   PARAMETER J1=2*JPANEE,J7=JPANEE+IPANEL
   EQUIVALENCE (BIGCX(1,1),AIJ(1,1))
   EQUIVALENCE (RHSD(1,1),BIJ(1,1))
   DIMENSION AIJ(IPANEL,IPANEL),BIJ(IPANEL,JPANEE)
   DIMENSION FNWW(IPANEL,IPANEL),FNWJ(IPANEL,JPANEE)
   DIMENSION AW(300),BA(300),CA(300),THETA(10),DA(300),AK(IPANEL)
   DIMENSION BIGCX(IPANEL,IPANEL),BONDN(ICW),AA(10),CX(ICW,ICW)
   DIMENSION RHSD(JPANEE,IPANEL)
   COMMON /AERO/ AM1,AM2,B1,B2,CL(30),CT(30),CD(30),GAM(2,100)
   COMMON /ADD/ CP(100),CM(30),BREAK(8),SWP(8,15),GAL(30),ISYM,VMU,VU
1  TEMP,FCR,CAMLER,CAMLET,CAMTER,CAMTET,XJ,YJ,ZJ,RJ,ALP,CREF,TWISTR
   COMMON /CONST/ NCS,NCW,M1(8),NSJ,NCJ(5),LAST,MJW1(3,5),MJW2(3,5),J
1  IPANEL,MJJ(5),NW(3),NNJ,NJP
   COMMON /CLOPE/ DZDXK(100),ALPA0(15),GCB(100),GCBX(100),THETAK(10)
1  CCX(100),OZDXK(100),GAN(2,100)
   COMMON /GEOM/ HALFSW,XCP(200),YCP(200),ZCP(200),XLE(50),YLE(50),XT
1  E(50),PSI(20),CH(95),XV(200),YV(100),SN( 8,8),XN(200,2),YN(200,2),
2  ZN(200,2),WIDTH(8),YCON(25),SWEEP(50),HALFB,SJ(21,8),EX(95,2),TX(
3  95,2),SC(160,5),SI(160,5),LC(3)
   COMMON /PARAM/ ALPT,ALFC,ALPS,CDF,SDF,TH,TDF
   COMMON /COST/ LTOTAL,LPAN1,NJW(5),LPANEL,IENTN,LPAN2,EXIT,PTIAL,TW
1  IST,DF(5),NFP
   CALL JETN04 (BA,RHSD,JPANEE,KCODE)
   CALL JETN05 (J7,AW,CA,RHSD,JPANEE)
   CALL JETN06 (AW,BA,CA,AIJ,BIJ,FNWW,FNWJ,IPANEL,J1,J7,CX,ICW)
   RETURN
   END
$   FORTY
$   INCODE  IBMF
SUBROUTINE JETN04 (BA,RHSD,JPANEE,KCODE)
C  SET UP THE RIGHT HAND SIDE MATRIX OF THE BOUNDARY CONDITIONS FOR
C  INDEX=1
   DIMENSION BA(1),RHSD(JPANEE,1)
   COMMON /AERO/ AM1,AM2,B1,B2,CL(30),CT(30),CD(30),GAM(2,100)
   COMMON /ADD/ CP(100),CM(30),BREAK(8),SWP(8,15),GAL(30),ISYM,VMU,VU

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1,TEMP,FCR,CAMLER,CAMLET,CAMTER,CAMTET,XJ,YJ,ZJ,RJ,ALP,CREF,TWISTR
COMMON /CONST/ NCS,NCW,M1(8),NSJ,NCJ(5),LAST,MJW1(3,5),MJW2(3,5),J
1PANEL,MJJ(5),NW(3),NNJ,NJP
COMMON /COST/ LTOTAL,LPAN1,NJW(5),LPANEL,IENTN,LPAN2,EXIT,PTIAL,TW
1IST,DF(5),NFP
COMMON /GEOM/ HALFSW,XCP(200),YCP(200),ZCP(200),XLE(50),YLE(50),XT
1E(50),PSI(20),CH(95),XV(200),YV(100),SN( 8,8),XN(200,2),YN(200,2),
2 ZN(200,2),WIDTH(8),YCON(25),SWEEP(50),HALFB,SJ(21,8),EX(95,2),TX(
395,2),SC(160,5),SI(160,5),LC(3)
COMMON /PARAM/ ALPT,ALPC,ALPS,CDF,SDF,TH,TDF
COMMON /SCHEME/ C(2),X(10,41),Y(10,41),SLOPE(15),XL(2,15),XTT(41),
1XLL(41)
VMUC=VMU*ALPC
IPHI=1
MJ=LPANEL+NCJ(1)
INN=1
JNN=1
DO 1 KI=1,JPANEL
LI=LAST+KI
KJ=LI
IF (LI .GT. LAST) KJ=LI-JPANEL
CALL STREAM (ALPHA,VMUC,LI,IPHI,LPANEL,TEMP,LPAN1,LPAN2,ISYM,
1KCODE,EXIT,MJ,1,BA)
IF (KJ .LT. MJ .OR. KJ .EQ. LAST) GO TO 50
IPHI=IPHI+1
MJ=MJ+NCJ(INN)
50 CONTINUE
MJI=MJJ(INN)-1
IF (KJ .EQ. MJI) GO TO 55
GO TO 60
55 JNN=INN
INN=INN+1
60 IF (KJ .EQ. MJJ(JNN)) IPHI=1
DO 2 I=1,LPANEL
2 RHSIDE(KI,I)=-BA(I)
1 CONTINUE
RETURN
END
$ FORTY
$ INCODE IBMF
SUBROUTINE JETN05 (J7,AW,CA,RHSIDE,JPANEE)
C FIND THE DERIVATIVES OF (DGOJ/DGWO) AND (DGWA/DGWO) AND STORE
C THOSE DERIVATIVES ON FILE (12)
DIMENSION AW(1),RHSIDE(JPANEE,1),CA(1)
COMMON /CONST/ NCS,NCW,M1(8),NSJ,NCJ(5),LAST,MJW1(3,5),MJW2(3,5),J
1PANEL,MJJ(5),NW(3),NNJ,NJP
COMMON /COST/ LTOTAL,LPAN1,NJW(5),LPANEL,IENTN,LPAN2,EXIT,PTIAL,TW
1IST,DF(5),NFP
REWIND 12
DO 1 I=1,LPANEL
REWIND 09

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DO 3 L=1,JPANEL
READ (09) (AW(M),M=1,LTOTAL)
3 CONTINUE
DO 2 J=1,J7
READ (09) (AW(M),M=1,LTOTAL)
CA(J)=0.0
DO 2 K=1,JPANEL
2 CA(J)=CA(J)+AW(K)*RHSIDE(K,I)
1 WRITE (12) (CA(M),M=1,J7)
RETURN
END
$ FORTY
$ INCODE IBMF
SUBROUTINE JETNO6(AW,BA,CA,AIJ,BIJ,FNWW,FNWJ,IPANEL,J1,J7,CX,ICW)
C FIND THE MATRICES (A) AND (B) AND STORE THOSE MATRICES
C ON FILE (11) , ALSO COMPUTE THE DERIVATIVES OF CAMBER SLOPES AND
C STORE IT ON FILE (10)
DIMENSION AW(1),BA(1),CA(1),AIJ(IPANEL,1),BIJ(IPANEL,1)
DIMENSION FNWW(IPANEL,1),FNWJ(IPANEL,1),CX(ICW,1)
COMMON /CONST/ NCS,NCW,M1(8),NSJ,NCJ(5),LAST,MJW1(3,5),MJW2(3,5),J
1PANEL,MJJ(5),NW(3),NNJ,NJP
COMMON /CLOPE/ DZDXK(100),ALPA0(15),GCB(100),GCBX(100),THETAK(10)
1,CCX(100),OZDXK(100),GAN(2,100)
COMMON /COST/ LTOTAL,LPAN1,NJW(5),LPANEL,IENTN,LPAN2,EXIT,PTIAL,TW
1IST,DF(5),NFP
DO 19 I=1,NCW
DO 19 J=1,NCW
IK=(I-1)*NCW+J
19 CX(I,J)=CCX(IK)
REWIND 03
DO 20 J=1,J1
READ (03) (AW(K),K=1,LTOTAL)
20 CONTINUE
DO 2 I=1,LPANEL
READ (03) (AW(K),K=1,LTOTAL)
DO 3 J=1,JPANEL
JJ=JPANEL+J
3 FNWJ(I,J)=AW(JJ)
DO 4 K=1,LPANEL
KK=J1+K
4 FNWW(I,K)=AW(KK)
2 CONTINUE
REWIND 11
DO 13 I=1,NCS
DO 13 IK=1,NCW
II=(I-1)*NCW+IK
DO 14 J=1,LPANEL
AIJ(II,J)=0.
DO 14 L=1,NCW
LL=(I-1)*NCW+L
14 AIJ(II,J)=AIJ(II,J)+CX(IK,L)*FNWW(LL,J)

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DO 15 JK=1,JPANEL
BIJ(II,JK)=0.
DO 15 LK=1,NCW
LN=(I-1)*NCW+LK
15 BIJ(II,JK)=BIJ(II,JK)+CX(IK,LK)*FNWJ(LN,JK)
13 CONTINUE
29 CONTINUE
DO 16 I=1,LPANEL
DO 11 IK=1,JPANEL
11 CA(IK)=BIJ(I,IK)
DO 12 JK=1,LPANEL
MK=JPANEL+JK
12 CA(MK)=AIJ(I,JK)
WRITE (11) (CA(LK),LK=1,J7)
16 CONTINUE
REWIND 12
REWIND 10
DO 8 I=1,LPANEL
REWIND 11
READ (12) (AW(L),L=1,J7)
DO 10 J=1,LPANEL
READ (11) (CA(L),L=1,J7)
BA(J)=0.0
DO 9 K=1,J7
9 BA(J)=BA(J)+CA(K)*AW(K)
10 BA(J)=AIJ(J,I)+BA(J)
WRITE (10) (BA(M),M=1,LPANEL)
8 CONTINUE
RETURN
END
$ LINK LINK66,LINK55
$ FORTY
$ INCODE IBMF
SUBROUTINE JETNOL(KCODE)
C THIS SUBROUTINE DETERMINE THE OPTIMUM CAMBER SHAPE AND TWIST
C DISTRIBUTION WITH SPECIFIED LIFT AND PITCHING MOMENT CONSTRAINTS
C IN THE JET ON CASE WITH UPPER-SURFACE-BLOWING AND ZERO LEADING
C EDGE SUCTION
PARAMETER IPANEL=60,ICW=6,JPANEE=80
PARAMETER J7=JPANEE+IPANEL,J1=2*JPANEE,LL1=(IPANEL+3)**2/4+1
DIMENSION GAMMA(LL1),CDII(20),OAMZC(IPANEL)
DIMENSION AW(300),BA(300),CA(300),DA(300),THETAI(10),PAMBD(2)
DIMENSION GAMMT(IPANEL),GAMAA(IPANEL),GAMOJ(JPANEE),GAT(IPANEL)
DIMENSION CAMZC(IPANEL),CONST(IPANEL),AK(IPANEL),RHS(300)
DIMENSION BONDN(ICW),WA(10),BIGCX(IPANEL,IPANEL),CX(ICW,ICW)
COMMON /ADD/ CP(100),CM(30),BREAK(8),SWP(8,15),GAL(30),ISYM,VMU,VU
1,TEMP,FCR,CAMLER,CAMLET,CAMTER,CAMTET,XJ,YJ,ZJ,RJ,ALP,CREF,TWISTR
COMMON /AERO/ AM1,AM2,B1,B2,CL(30),CT(30),CD(30),GAM(2,100)
COMMON /CLOPE/ DZDXK(100),ALPA0(15),GCB(100),GCBX(100),THETAK(10)
1,CCX(100),OZDXK(100),GAN(2,100)
COMMON /LING/ GLBAR,GMBAR,FCLII,FCMII

```

```

COMMON /WLONG/ DZDXKW(100),GAMW(100),CAMZCW(100),ALPAOW(20)
COMMON /CONST/ NCS,NCW,M1(8),NSJ,NCJ(5),LAST,MJW1(3,5),MJW2(3,5),J
1PANEL,MJJ(5),NW(3),NNJ,NJP
COMMON /COST/ LTOTAL,LPAN1,NJW(5),LPANEL,IENTN,LPAN2,EXIT,PTIAL,TW
1IST,DF(5),NFP
COMMON /GEOM/ HALFSW,XCP(200),YCP(200),ZCP(200),XLE(50),YLE(50),XT
1E(50),PSI(20),CH(95),XV(200),YV(100),SN( 8,8),XN(200,2),YN(200,2),
2.ZN(200,2),WIDTH(8),YCON(25),SWEEP(50),HALFB,SJ(21,8),EX(95,2),TX(
395,2),SC(160,5),SI(160,5),LC(3)
COMMON /PARAM/ ALPT,ALPC,ALPS,CDF,SDF,TH,TDF
COMMON /IDENT/ DZDXK1(100),GAM1(100),CAMZC1(100),ALPA01(20),YLE1(2
10)
CALL INVRGX (THETAI,BONDN,WA,IPANEL,BIGCX,AK,ICW,CX)
13 FORMAT (3F10.5,I10)
14 FORMAT (1H,'CLII,CMII,DELTA,MAXP')
15 FORMAT (1H,'NUMB,SIZE')
33 FORMAT (I10,F10.5)
DO 44 I=1,NCS
ALPAOW(I)=0.
DO 46 J=1,NCS
AA=1.
DO 47 L=1,NCS
IF (L.EQ.J) GO TO 47
AA=AA*(YLE(I)-YLE1(L))/(YLE1(J)-YLE1(L))
47 CONTINUE
ALPAOW(I)=ALPAOW(I)+AA*ALPA01(J)
46 CONTINUE
44 CONTINUE
DO 4 I=1,NCS
DO 5 K=1,NCW
JJ=(I-1)*NCW+K
GAMW(JJ)=0.
CAMZCW(JJ)=0.
DZDXKW(JJ)=0.
DO 6 J=1,NCS
II=(J-1)*NCW+K
AA=1.
DO 7 L=1,NCS
IF (L.EQ.J) GO TO 7
AA=AA*(YLE(I)-YLE1(L))/(YLE1(J)-YLE1(L))
7 CONTINUE
GAMW(JJ)=GAMW(JJ)+AA*GAM1(II)
DZDXKW(JJ)=DZDXKW(JJ)+AA*DZDXK1(II)
CAMZCW(JJ)=CAMZCW(JJ)+AA*CAMZC1(II)
6 CONTINUE
5 CONTINUE
4 CONTINUE
DO 20 I=1,LPANEL
DZDXK(I)=DZDXKW(I)
GAM(1,I)=GAMW(I)
20 GAM(2,I)=GAM(1,I)

```

```

C
C *** LIFT CONSTRAINT, PITCHING MOMENT CONSTRAINT, INITIAL STEP SIZE
C AND MAXIMUM NUMBER OF ITERATIONS ***
C   WRITE (6,14)
C   READ (5,13) CLBAR,CMBAR,DELTO,MAXP
C   WRITE (6,13)CLBAR,CMBAR,DELTO,MAXP
C
C *** NUMBER OF INTERMEDIATE CYCLES WHICH ARE NEEDED TO REDUCE THE
C INITIAL COMPUTED LIFT AND PITCHING MOMENT COEFFICIENTS TO THE
C CONSTRAINTS, THE ASSUMED STEP SIZE IN THE JET ON CASE ***
C   WRITE (6,15)
C   READ (5,33) NUMB,SIZE
C   WRITE (6,33) NUMB,SIZE
C
C   N=0
C   ITN=0
C   NCOUNT=0
38  CONTINUE
C   IF (ABS(CLII-CLBAR).LT.0.00001) GO TO 508
C   IF (ITN.GT.2) GO TO 502
C   GO TO 590
508  CONTINUE
C   NCOUNT=NCOUNT+1
C   DO 560 I=1,LPANEL
C   OAMZC(I)=CAMZC(I)
560  CONTINUE
C   WRITE (6,565) NCOUNT,DELTA
565  FORMAT (1H0,'THE',I3,'TH  ITERATION IN THE FINAL CYCLE, DELTA=',
1F10.3)
590  CONTINUE
C   N=N+1
502  CONTINUE
C   DO 31 I=1,LPANEL
C   OCLII=CLII
C   OCMII=CMII
C   GAN(1,I)=GAM(1,I)
C   GAN(2,I)=GAM(2,I)
C   GAT(I)=GAMMT(I)
C   OZDXK(I)=DZDXK(I)
31  CONTINUE
C   IF (ABS(CLII-CLBAR).LT.0.00001) GO TO 505
C   IF (ITN.GT.2) GO TO 19
C   IF (N.EQ.1) GO TO 32
505  CONTINUE
C   IF (ABS(CLII-CLBAR).GT.0.00001) WRITE (6,200) DELTA,ITN,NUMB1
200  FORMAT (1H0,'DELTA=',F10.3,5X,I2,'TH  ITERATION OF',I2,'TH  INTER
1MEDIATE CYCLES')
C   CALL JETN07 (GAMMA,BA,DELTA,AW,CA,CLII,CMII,PAMBDA,GAT,J7)
32  CONTINUE
C   CALL JETN08 (RHS,KCODE)
C   CALL JETN09 (GAMMT,GAM0J,GAMAA,RHS,AW,BA,CA,J7,N,CDII,CLII,CMII,

```

```

1CLBAR,CMBAR,NUMB,ITN)
  IF (N.EQ.1) CALL CAMBER (AK,CAMZC,CONST,GAMMA,BA,N,MAXP)
  IF (N.EQ.1) CALL LOAD
  IF (ABS(CLII-CLBAR).LT.0.00001) GO TO 555
  IF (N.EQ.1) GO TO 80
  IF (ITN.EQ.1) GO TO 89
555  CONTINUE
     IF (CDII(ITN).GT.CDII(ITN-1)) GO TO 29
89   ITN=ITN+1
     GO TO 79
19   CONTINUE
     FCLII=FCLII-GLBAR
     FCMII=FCMII-GMBAR
     NUMB1=NUMB1+1
     DELTA=DELTO
     ITN=1
     GO TO 68
29   CONTINUE
     DELTA=0.5*DELTA
     ITN=ITN+1
     DO 49 I=1,LPANEL
       GAM(1,I)=GAN(1,I)
       GAM(2,I)=GAN(2,I)
       GAMMT(I)=GAT(I)
       DZDXK(I)=OZDXK(I)
       CLII=OCLII
       CMII=OCMII
49   CONTINUE
     GO TO 68
80   ITN=1
     DELTA=DELTO
     NUMB1=1
     GO TO 68
79   CONTINUE
     IF (ABS(CLII-CLBAR).LT.0.00001) GO TO 540
     IF (ITN.GT.2) GO TO 68
540  DELTA=SIZE
68   CONTINUE
     IF (ABS(CLII-CLBAR).LT.0.00001) CALL CAMBER (AK,CAMZC,CONST,GAMMA,
1BA,N,MAXP)
     IF (NCOUNT.EQ.0) GO TO 561
     SUM=0.
     DO 562 I=1,LPANEL
       SUM=SUM+(CAMZC(I)-OAMZC(I))**2
562  CONTINUE
     RMS=SQRT(SUM)/(FLOAT(LPANEL)*CREF)
     WRITE (6,563) RMS
563  FORMAT (1H,'THE ROOT MEAN SQUARE OF CAMBER ORDINATES=',F15.5)
561  CONTINUE
     IF (N.LT.MAXP) GO TO 38
     CALL LOAD

```


RETURN
END

```

$   FORTY
$   INCODE  IBMF
C   SUBROUTINE JETNO7 (GAMMA,BA,DELTA,AW,CA,CLII,CMII,PAMBDA,GAT,J7)
    CALCULATE THE NEW WING-ALONE VORTEX STRENGTH AND THE CAMBER SLOPE
    DIMENSION AW(1),BA(1),CA(1),GAMMA(1),PAMBDA(1),GAT(1)
    COMMON /AERO/ AM1,AM2,B1,B2,CL(30),CT(30),CD(30),GAM(2,100)
    COMMON /CLOPE/ DZDXK(100),ALPA0(15),GCB(100),GCBX(100),THETAK(10)
    1,CCX(100),OZDXK(100),GAN(2,100)
    COMMON /CONST/ NCS,NCW,M1(8),NSJ,NCJ(5),LAST,MJW1(3,5),MJW2(3,5),J
    1PANEL,MJJ(5),NW(3),NNJ,NJP
    COMMON /GEOM/ HALFSW,XCP(200),YCP(200),ZCP(200),XLE(50),YLE(50),XT
    1E(50),PSI(20),CH(95),XV(200),YV(100),SN( 8,8),XN(200,2),YN(200,2),
    2 ZN(200,2),WIDTH(8),YCON(25),SWEEP(50),HALFB,SJ(21,8),EX(95,2),TX(
    395,2),SC(160,5),SI(160,5),LC(3)
    COMMON /LING/ GLBAR,GMBAR,FCLII,FCMII
    COMMON /COST/ LTOTAL,LPAN1,NJW(5),LPANEL,IENTN,LPAN2,EXIT,PTIAL,TW
    1IST,DF(5),NFP
    PI=3.14159265
    L1=LPANEL+1
    L2=LPANEL+2
    L3=LPANEL+3
    REWIND 12
    REWIND 10
    REWIND 08
    DO 71 I=1,LPANEL
    DO 72 J=1,LPANEL
    IF (J.EQ. I) GO TO 73
    CA(J)=0.0
    GO TO 72
    73 CA(J)=1.0
    72 CONTINUE
    READ (12) (AW(L),L=1,J7)
    CA(L1)=0.0
    CA(L2)=0.0
    DO 60 L=1,LPANEL
    LL=JPANEL+L
    CA(L1)=CA(L1)+GCB(L)*AW(LL)
    60 CA(L2)=CA(L2)+GCBX(L)*AW(LL)
    CA(L1)=CA(L1)+GCB(I)
    CA(L2)=CA(L2)+GCBX(I)
    CA(L1)=PI**2*CA(L1)*DELTA/(HALFSW*2.)
    CA(L2)=PI**2*CA(L2)*DELTA/(HALFSW*2.)
    BDGW=0.0
    DO 14 M=1,LPANEL
    MM=JPANEL+M
    BDGW=BDGW+(GCB(M)*OZDXK(M)*AW(MM))
    14 CONTINUE
    ADGW=0.0
    READ (10) (BA(L),L=1,LPANEL)

```

```

DO 74 K=1,LPANEL
ADGW=ADGW+(GCB(K)*BA(K)*GAT(K))
74 CONTINUE
ADGW=-(ADGW+BDGW+GCB(I)*OZDXK(I))
CA(L3)=ADGW*PI**2*DELTA/(HALFSW*2.)
WRITE (08) (CA(KK),KK=1,L3)
71 CONTINUE
REWIND 12
DO 75 K=1,LPANEL
READ (12) (AW(J),J=1,J7)
CA(K)=0.0
DO 16 I=1,LPANEL
II=JPANEL+I
CA(K)=CA(K)+GCB(I)*AW(II)
16 CONTINUE
CA(K)=GCB(K)+CA(K)
CA(K)=CA(K)*PI*PI/(HALFSW*2.)
75 CONTINUE
CA(L1)=0.0
CA(L2)=0.0
CA(L3)=CLII-FCLII
WRITE (08) (CA(J),J=1,L3)
REWIND 12
DO 76 L=1,LPANEL
READ (12) (AW(I),I=1,J7)
CA(L)=0.0
DO 18 J=1,LPANEL
JJ=JPANEL+J
CA(L)=CA(L)+GCBX(J)*AW(JJ)
18 CONTINUE
CA(L)=GCBX(L)+CA(L)
CA(L)=CA(L)*PI*PI/(HALFSW*2.)
76 CONTINUE
CA(L1)=0.0
CA(L2)=0.0
CA(L3)=CMII-FCMII
WRITE (08) (CA(J),J=1,L3)

```

```

C
REWIND 08
READ (03) (AW(I),I=1,L3)
DO 77 I=1,L2
GAMMA(I)=-AW(I+1)/AW(1)
77 CONTINUE
NJ=L2-1
DO 78 IJ=2,L2
READ (08) (AW(I),I=1,L3)
IK=IJ
CALL VMSEQN (NJ,IK,AW,GAMMA,CA)
NJ=NJ-1
78 CONTINUE
PAMBDA(1)=GAMMA(L1)

```

```

PAMBDA(2)=GAMMA(L2)
DO 36 I=1,LPANEL
  GAM(1,I)=GAN(1,I)+GAMMA(I)
  GAM(2,I)=GAN(2,I)+GAMMA(I)
36 CONTINUE
  REWIND 04
  DO 21 I=1,LPANEL
    READ (04) (AW(K),K=1,LPANEL)
    DZDXK(I)=0.
    DO 22 J=1,LPANEL
      DZDXK(I)=DZDXK(I)+AW(J)*GAM(1,J)
22 CONTINUE
21 CONTINUE
  RETURN
  END

$   FORTY
$   INCODE  IBMF
SUBROUTINE JETN08 (RHS,KCODE)
C   SET UP THE RIGHT HAND SIDE VECTORS OF THE BOUNDARY CONDITIONS
C   FOR INDEX=2
  DIMENSION RHS(1)
  COMMON /AERO/ AM1,AM2,B1,B2,CL(30),CT(30),CD(30),GAM(2,100)
  COMMON /ADD/ CP(100),CM(30),BREAK(8),SWP(8,15),GAL(30),ISYM,VMU,VU
1,TEMP,FCR,CAMLER,CAMLET,CAMTER,CAMTET,XJ,YJ,ZJ,RJ,ALP,CREF,TWISTR
  COMMON /CONST/ NCS,NCW,M1(8),NSJ,NCJ(5),LAST,MJW1(3,5),MJW2(3,5),J
1PANEL,MJJ(5),NW(3),NNJ,NJP
  COMMON /COST/ LTOTAL,LPAN1,NJW(5),LPANEL,IENTN,LPAN2,EXIT,PTIAL,TW
1IST,DF(5),NFP
  COMMON /GEOM/ HALFSW,XCP(200),YCP(200),ZCP(200),XLE(50),YLE(50),XT
1E(50),PSI(20),CH(95),XV(200),YV(100),SN( 8,8),XN(200,2),YN(200,2),
2 ZN(200,2),WIDTH(8),YCON(25),SWEEP(50),HALFB,SJ(21,8),EX(95,2),TX(
395,2),SC(160,5),SI(160,5),LC(3)
  COMMON /PARAM/ ALPT,ALPC,ALPS,CDF,SDF,TH,TDF
  COMMON /SCHEME/ C(2),X(10,41),Y(10,41),SLOPE(15),XL(2,15),XTT(41),
1XLL(41)
  NA=3
  IF (NW(2) .EQ. 0) NA=1
  IF (NW(2).NE. 0 .AND. NW(3) .EQ. 0) NA=2
  ZZ=YCON(25)
  DFJ=CDF
  VMUC=VMU*ALPC
  IPHI=1
  MJ=LPANEL+NCJ(1)
  INN=1
  JNN=1
  KI=1
  LI=LAST+1
  IH=NW(NA)+MJW1(NA,NJP)-1
40 KJ=LI
  IF (LI .GT. LAST) KJ=LI-JPANEL
  CALL STREAM (ALPHA,VMUC,LI,IPHI,LPANEL,TEMP,LPAN1,LPAN2,ISYM,

```

```
1KCODE,EXIT,MJ,2,BA)
```

```
IF (KCODE .EQ. 0) GO TO 63
```

```
IF (ZZ .GE. 0.01) GO TO 63
```

C
C
C
C
C
C

```
ADDITIONAL EXTERNAL FLOW DEFLECTION IS ALLOWED IF THE JET ANGLE IS  
GREATER THAN THE FLAP ANGLE BECAUSE OF THE EFFECT OF FINITE TRAIL-  
LING-EDGE ANGLES. FOR THIN AIRFOILS, THIS CAN BE ELIMINATED BY  
INSERTING THE STATEMENT, IF (KCODE.EQ.1) GO TO 63
```

```
IF (LI .GE. MJW1(NA,NJP) .AND. LI .LE. MJW2(NA,NJP)) GO TO 62  
GO TO 63
```

```
62 IF (LI .NE. IH) GO TO 63
```

```
IF((DFJ-TDF) .LT. 0.) GO TO 63
```

```
CZT=CAMTER-(CAMTER-CAMTET) *YCP(LI)/HALFB
```

```
APA=0.5*(DFJ-TDF+CZT)
```

```
IF (VMU .GT. 0.85) APA=APA*(1.-VMU)/0.15
```

```
IF (APA .LT. 0.) APA=0.
```

```
ALPHA=ALPHA+APA
```

```
IH=IH+NW(NA)
```

```
63 CONTINUE
```

```
RHS(KI)=-ALPHA
```

```
45 IF (KJ .LT. MJ .OR. KJ .EQ. LAST) GO TO 50
```

```
IPHI=IPHI+1
```

```
MJ=MJ+NCJ(INN)
```

```
50 CONTINUE
```

```
MJI=MJJ(INN)-1
```

```
IF (KJ .EQ. MJI) GO TO 55
```

```
GO TO 60
```

```
55 JNN=INN
```

```
INN=INN+1
```

```
60 IF (KJ .EQ. MJJ(JNN)) IPHI=1
```

```
IF (LI .EQ. LTOTAL) GO TO 65
```

```
GO TO 70
```

```
65 CONTINUE
```

```
IPHI=1
```

```
MJ=L PANEL+NCJ(1)
```

```
JNN=1
```

```
INN=1
```

```
70 CONTINUE
```

```
KI=KI+1
```

```
IF (LI .EQ. LTOTAL) GO TO 75
```

```
IF (LI .EQ. LAST) GO TO 80
```

```
LI=LI+1
```

```
GO TO 85
```

```
75 LI=L PANEL+1
```

```
GO TO 85
```

```
80 LI=1
```

```
85 CONTINUE
```

```
IF (KI .LE. LTOTAL) GO TO 40
```

```
RETURN
```

```
END
```

```

$      FORTY
$      INCODE  IBMF
SUBROUTINE JETN09 (GAMMT,GAMOJ,GAMAA,RHS,AW,BA,CA,J7,N,CDII,CLII,
1CMII,CLBAR,CMBAR,NUMB,ITN)
C      FIND THE JET VORTICES IN THE OUTER FLOW AND THE WING ADDITIONAL
C      VORTICES
      DIMENSION AW(1),BA(1),RHS(1),GAMMT(1),GAMOJ(1),GAMAA(1)
      DIMENSION CDII(1),CA(1)
      COMMON /AERO/ AM1,AM2,B1,B2,CL(30),CT(30),CD(30),GAM(2,100)
      COMMON /CLOPE/ DZDXK(100),ALPA0(15),GCB(100),GCBX(100),THETAK(10)
1,CCX(100),OZDXK(100),GAN(2,100)
      COMMON /LING/ GLBAR,GMBAR,FCLII,FCMII
      COMMON /ADD/ CP(100),CM(30),BREAK(8),SWP(8,15),GAL(30),ISOM,VMU,VU
1,TEMP,FCR,CAMLER,CAMLET,CAMTER,CAMTET,XJ,YJ,ZJ,RJ,ALP,CREF,TWISTR
      COMMON /PARAM/ ALPT,ALPC,ALPS,CDF,SDF,TH,TDF
      COMMON /GEOM/ HALFSW,XCP(200),YCP(200),ZCP(200),XLE(50),YLE(50),XT
1E(50),PSI(20),CH(95),XV(200),YV(100),SN( 8,8),XN(200,2),YN(200,2),
2 ZN(200,2),WIDTH(8),YCON(25),SWEEP(50),HALFB,SJ(21,8),EX(95,2),TX(
395,2),SC(160,5),SI(160,5),LC(3)
      COMMON /CONST/ NCS,NCW,M1(8),NSJ,NCJ(5),LAST,MJW1(3,5),MJW2(3,5),J
1PANEL,MJJ(5),NW(3),NNJ,NJP
      COMMON /COST/ LTOTAL,LPAN1,NJW(5),LPANEL,IENTN,LPAN2,EXIT,PTIAL,TW
1IST,DF(5),NFP
      PI=3.14159265
      REWIND 09
      DO 9 I=1,JPANEL
      READ (09) (AW(K),K=1,LTOTAL)
9      CONTINUE
      DO 1 I=1,J7
      READ (09) (AW(K),K=1,LTOTAL)
      BA(I)=0.0
      DO 2 J=1,LTOTAL
2      BA(I)=BA(I)+AW(J)*RHS(J)
1      CONTINUE
      DO 3 I=1,JPANEL
      GAMOJ(I)=BA(I)
3      CONTINUE
      DO 4 I=1,LPANEL
      II=JPANEL+I
      GAMAA(I)=BA(II)
4      CONTINUE
      DO 5 I=1,LPANEL
      GAMMT(I)=GAM(1,I)+GAMAA(I)
5      CONTINUE
      DO 21 I=1,LPANEL
      CP(I)=GAMMT(I)*2.*ALPC
21     CONTINUE
      CLII=0.0
      CMII=0.0
      CDII(ITN)=0.0
      DO 50 I=1,LPANEL

```

```

CDII(ITN)=CDII(ITN)+GCB(I)*DZDXK(I)*GAMMT(I)
CLII=CLII+GCB(I)*GAMMT(I)
CMII=CMII+GCBX(I)*GAMMT(I)
50 CONTINUE
CDII(ITN)=-PI**2*CDII(ITN)/(HALFSW*2.)
CLII=PI*PI*CLII/(HALFSW*2.)
CMII=PI*PI*CMII/(HALFSW*2.)
WRITE (6,134) CDII(ITN)
134 FORMAT (1H,'INDUCED DRAG COEFFICIENT, CDII=',F15.5)
WRITE (6,135) CLII
135 FORMAT (1H,'LIFT COEFFICIENT, CLII=',F15.5)
WRITE (6,136) CMII
136 FORMAT (1H,'PITCHING MOMENT COEFFICIENT, CMII=',F15.5)
IF (N.GT.1) GO TO 30
DLBAR=CLII-CLBAR
DMBAR=CMII-CMBAR
GLBAR=DLBAR/NUMB
GMBAR=DMBAR/NUMB
FCLII=CLII-GLBAR
FCMII=CMII-GMBAR
30 CONTINUE
RETURN
END
S FORTY
S INCODE IBMF
C SUBROUTINE CAMBER (AK,CAMZC,CONST,GAMMA,BA,NBC,MAXP)
C COMPUTE THE CAMBER ORDINATES AND THE TWIST DISTRIBUTION
C DIMENSION ALPA(15)
C DIMENSION AK(1),CAMZC(1),CONST(1),GAMMA(1),BA(1)
C COMMON /CLOPE/ DZDXK(100),ALPA0(15),GCB(100),GCBX(100),THETAK(10)
C 1,CCX(100),OZDXK(100),GAN(2,100)
C COMMON /GECM/ HALFSW,XCP(200),YCP(200),ZCP(200),XLE(50),YLE(50),XT
C 1E(50),PSI(20),CH(95),XV(200),YV(100),SN( 8,8),XN(200,2),YN(200,2),
C 2 ZN(200,2),WIDTH(8),YCCN(25),SWEEP(50),HALFB,SJ(21,8),EX(95,2),TX(
C 395,2),SC(160,5),SI(160,5),LC(3)
C COMMON /CONST/ NCS,NCW,M1(8),NSJ,NCJ(5),LAST,MJW1(3,5),MJW2(3,5),J
C 1PANEL,MJJ(5),NW(3),NNJ,NJP
C COMMON /WLCNE/ DZDXKW(100),GAMW(100),CAMZCW(100),ALPAOW(20)
C COMMON /COST/ LTOTAL,LPAN1,NJW(5),LPANEL,IENTN,LPAN2,EXIT,PTIAL,TW
C 1IST,DF(5),NFP
102 FORMAT (1H,'THE TWIST DISTRIBUTION IN THE SPANWISE DIRECTION')
PI=3.14159265
NW2=NW(1)+NW(2)
IF (NW(2).EQ.0) GO TO 48
II=NCS+1
IF (NW(3) .NE. 0) GO TO 50
CHORD=CH(1)+CH(II)
XX1=CH(1)/CHORD
THETA1=ARCOS(1.-2.*XX1)
THETA2=PI
GO TO 51

```

```

50  III=II+NCS
    CHORD=CH(1)+CH(II)+CH(III)
    XX1=CH(1)/CHORD
    THETA1=ARCOS(1.-2.*XX1)
    XX2=(CH(1)+CH(II))/CHORD
    THETA2=ARCOS(1.-2.*XX2)
51  CONTINUE
    GO TO 49
48  THETA1=PI
49  CONTINUE
    K1=1
    K2=2
    IF (NBC.EQ.1 .OR. NBC.EQ.MAXP) WRITE (6,102)
    DO 23 KI=1,NCS
    DO 25 N=1,NCW
    NA=(KI-1)*NCW+N
    AK(NA)=0.0
    FN=N-1
    DO 27 L=1,NCW
    IF (L.LE.NW(1)) KB=(KI-1)*NW(1)+L
    IF (L.GT.NW(1) .AND. L.LE.NW2) KB=LPAN1+(KI-1)*NW(2)+L-NW(1)
    IF (L.GT.NW2) KB=LPAN2+(KI-1)*NW(3)+L-NW2
    IF (L.LE.NW(1)) GO TO 100
    IF (L.GT.NW(1) .AND. L.LE.NW2) GO TO 200
    IF (L.GT.NW2) GO TO 300
100  FNW=NW(1)
    THETA=THETA1
    GO TO 400
200  FNW=NW(2)
    THETA=THETA2-THETA1
    GO TO 400
300  FNW=NW(3)
    THETA=PI-THETA2
400  CONTINUE
    AK(NA)=AK(NA)+THETA*DZDXK(KB)*COS(FN*THETA*(L))/(FNW*PI)
27  CONTINUE
    IF (N.GT.1) AK(NA)=2.*AK(NA)
25  CONTINUE
    CONST1=0.0
    CONST2=0.0
    DO 88 J=3,NCW
    GK=J-1
    KG=(KI-1)*NCW+J
    CONST1=CONST1+0.25*AK(KG)*(1./(1.-GK)+1./(1.+GK))
    CONST2=CONST2+0.25*AK(KG)*(1./(1.-GK)*COS((1.-GK)*PI)+1./(1.+GK)*C
10S((1.+GK)*PI))
88  CONTINUE
    CONST3=0.125*AK(K2)
    CONST(KI)=CONST1+CONST3
    ALPA0(KI)=CONST2-CONST1-AK(K1)
    ALPA(KI)=ALPA0(KI)*180./PI

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DO 29 M=1,NCW
MM=(KI-1)*NCW+M
CAMZC(MM)=0.0
DO 30 K=3,NCW
FK=K-1
KD=(KI-1)*NCW+K
CAMZC(MM)=CAMZC(MM)-0.25*AK(KD)*(1./(1.-FK)*COS((1.-FK)*THETAK(M))
1+1./(1.+FK)*COS((1.+FK)*THETAK(M)))
30 CONTINUE
CONST4=-CONST3*COS(2.*THETAK(M))
CAMZC(MM)=CAMZC(MM)+(ALPA0(KI)+AK(K1))*0.5*(1.-COS(THETAK(M)))+CON
1ST4+CONST(KI)
29 CONTINUE
K1=K1+NCW
K2=K2+NCW
IF (NBC.EQ.1 .OR. NBC.EQ.MAXP) WRITE (6,126)KI,YLE(KI),KI,ALPA(KI)
126 FORMAT (1H,'YLE(',I2,')=',F15.5,5X,'ALPA0(',I2,')=',F15.5)
23 CONTINUE
IF (NBC.EQ.1 .OR. NBC.EQ.MAXP) WRITE (6,129)
129 FORMAT (1H,'CAMBER ORDINATES IN THE JET ON CASE')
IF (NBC.EQ.1 .OR. NBC.EQ.MAXP)WRITE(6,127)(CAMZC(JJ),JJ=1,LPANEL)
127 FORMAT (1H,6F10.5)
RETURN
END
$ FORTY
$ LIMITS ,30K
$ INCODE IBMF
SUBROUTINE LOAD
C TO EVALUATE THE AERODYNAMIC CHARACTERISTICS
DIMENSION CA(30),CPSWL(30),AW(30)
COMMON /AERO/ AM1,AM2,E1,B2,CL(30),CT(30),CD(30),GAM(2,100)
COMMON /ADD/ CP(100),CM(30),BREAK(8),SWP(8,15),GAL(30),ISYM,VMU,VU
1,TEMP,FCR,CAMLER,CAMLET,CAMTER,CAMTET,XJ,YJ,ZJ,RJ,ALP,CREF,TWISTR
COMMON /CLOPE/ DZDXK(100),ALPA0(15),GCB(100),GCBX(100),THETAK(10)
1,CCX(100),OZDXK(100),GAN(2,100)
COMMON /LING/ GLBAR,GMEAR,FCLII,FCMII
COMMON /WLONE/ DZDXKW(100),GAMW(100),CAMZCW(100),ALPAOW(20)
COMMON /CONST/ NCS,NCW,M1(8),NSJ,NCJ(5),LAST,MJW1(3,5),MJW2(3,5),J
1PANEL,MJJ(5),NW(3),NNJ,NJP
COMMON /GEOM/ HALFSW,XCP(200),YCP(200),ZCP(200),XLE(50),YLE(50),XT
1E(50),PSI(20),CH(95),XV(200),YV(100),SN( 8,8),XN(200,2),YN(200,2),
2 ZN(200,2),WIDTH(8),YCCN(25),SWEEP(50),HALFB,SJ(21,8),EX(95,2),TX(
395,2),SC(160,5),SI(160,5),LC(3)
COMMON /PARAM/ ALPT,ALPC,ALPS,CDF,SDF,TH,TDF
COMMON /COST/ LTOTAL,LPAN1,NJW(5),LPANEL,IENTN,LPAN2,EXIT,PTIAL,TW
1IST,DF(5),NFP
COMMON /SCHEME/ C(2),X(10,41),Y(10,41),SLOPE(15),XL(2,15),XTT(41),
1XLL(41)
1 FORMAT (1H0,26X,7HALPHA =,F10.3,3X,7HDEGREES)
2 FORMAT (1H0,20X,40HXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX)
101 FORMAT (1H1)

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PI=3.14159265
DO 18 I=1,NCS
CT(I)=0.
XTE(I)=0.
X(5,I)=0.
18 CONTINUE
ALPH=ALP*180./PI
WRITE (6,101)
WRITE (6,2)
WRITE (6,1) ALPH
WRITE (6,2)
ZJET=YCON(25)
IUSB=YCON(24)
NC=IENTN
DFJ=CDF
CMU=C(1)
CLT=0.
CMT=0.
CDT=0.
CLW=0.
CMWT=0.
CDW=0.
CLWW=0.
CMWWT=0.
CDWW=0.
KC=1
NCOL=M1(1)
KLL=0
MM=0
IU=1
IF (NW(2) .NE. 0) IU=2
IF (NW(3) .NE. 0) IU=3
NW2=NW(1)+NW(2)
NW3=NW(2)+NW(3)
NCW1=NCW+1
NL=1
DO 150 I=1,NCS
IF (NW(2) .EQ. 0) GO TO 160
II=I+NCS
IF (NW(3) .NE. 0) GO TO 144
CHORD=CH(I)+CH(II)
GO TO 161
144 III=II+NCS
CHORD=CH(I)+CH(II)+CH(III)
GO TO 161
160 CHORD=CH(I)
161 CONTINUE
CML=C.
CL(I)=0.
CD(I)=0.
CA(I)=0.

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CMW=0.
CPSWL(I)=0.
CMWw=0.
X(4,I)=0.
X(6,I)=0.
X(7,I)=0.
DO 155 J=1,NCW
NN=J+MM
IF (NW(2) .EQ. 0) GO TO 151
IF (J .LE. NW(1)) GO TO 151
IF (J .GT. NW2) GO TO 153
LL=LPAN1+NW(2)*(I-1)+J-NW(1)
IL=II
JLL=J-NW(1)
L=2
FN=NW(2)
GO TO 152
153 LL=LPAN2+NW(3)*(I-1)+J-NW2
IL=III
JLL=J-NW2
L=3
FN=NW(3)
GO TO 152
151 LL=NN
IL=I
JLL=J
L=1
FN=NW(1)
152 CONTINUE
XC=(XV(LL)-XLE(I))/CHORD
X(1,J)=0.
X(2,J)=0.
510 GBS=CP(LL)*SN(JLL,L)*CH(IL)/(2.*FN)
WBS=GAMW(LL)*SN(JLL,L)*CH(IL)*ALPC/FN
WAS=GAMW(LL)*SN(JLL,L)*CH(IL)*ALPC/FN
IF (DF(NL) .LE. 0.001) GO TO 521
IF (PTIAL .LE. 0.1) GO TO 520
IF (NW(3) .EQ. 0) GO TO 524
IF (LL .GE. MJW1(3,NL) .AND. LL .LE. MJW2(3,NL)) GO TO 523
521 CS=1.
SS=-DZDXK(LL)
SW=-DZDXKW(LL)
GO TO 522
520 IF (NW(2) .NE. 0 .AND. LL .LE. LPAN1) GO TO 521
IF (NW(3) .NE. 0 .AND. LL .LE. LPAN2) GO TO 521
523 CS=1.
SS=-DZDXK(LL)
SW=-DZDXKW(LL)
GO TO 522
524 IF (LL .GE. MJW1(2,NL) .AND. LL .LE. MJW2(2,NL)) GO TO 523
GO TO 521

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522 CONTINUE
   CL(I)=CL(I)+GBS*CS
   CML=CML-GBS*XV(LL)*CS
   CD(I)=CD(I)+GBS*SS
   CA(I)=CA(I)+WBS*CS
   CMW=CMW-WBS*XV(LL)*CS
   CPSWL(I)=CPSWL(I)+WBS*SS
   X(4,I)=X(4,I)+WAS*CS
   CMWW=CMWW-WAS*XV(LL)*CS
   X(6,I)=X(6,I)+WAS*SW
155 CONTINUE
   CAMLE=CAMLER-(CAMLER-CAMLET)*YLE(I)/HALFB
   EPHA=XLL(I)-ATAN(CAMLE)
   X(1,NCW1)=COS(EPHA)
   X(2,NCW1)=SIN(EPHA)
   CL(I)=CL(I)*PI/CHORD+CT(I)*X(2,NCW1)
   CM(I)=CML*PI/(CREF*CHORD)
   CD(I)=CD(I)*PI/CHORD-CT(I)*X(1,NCW1)
   CA(I)=CA(I)*PI/CHORD+XTE(I)*X(2,NCW1)
   AW(I)=CMW*PI/(CREF*CHORD)
   CPSWL(I)=CPSWL(I)*PI/CHORD-XTE(I)*X(1,NCW1)
   X(4,I)=X(4,I)*PI/CHORD+X(5,I)*X(2,NCW1)
   X(7,I)=CMWW*PI/(CREF*CHORD)
   X(6,I)=X(6,I)*PI/CHORD-X(5,I)*X(1,NCW1)
   IF (I .LT. NCOL) GO TO 210
   KLL=NCOL-1
   KC=KC+1
   NCOL=NCOL+M1(KC)-1
210 KL=I-KLL
   FM=M1(KC)
   AA=CHORD*SJ(KL,KC)*WIDTH(KC)/FM
   CLT=CLT+CL(I)*AA
   CMT=CMT+CM(I)*AA
   CDT=CDT+CD(I)*AA
   CLW=CLW+CA(I)*AA
   CMWT=CMWT+AW(I)*AA
   CDW=CDW+CPSWL(I)*AA
   CLWW=CLWW+X(4,I)*AA
   CMWWT=CMWWT+X(7,I)*AA
   CDWW=CDWW+X(6,I)*AA
   MM=(NCW-NW3)*I
   IF (LL.EQ. MJW2(IU,NL)) NL=NL+1
150 CONTINUE
   CLT=CLT*PI/(2.*HALFSW)
   CMT=CMT*PI/(2.*HALFSW)
   CDT=CDT*PI/(2.*HALFSW)
   CDCL2=CDT/(CLT*CLT)
   CLW=CLW*PI/(2.*HALFSW)
   CMWT=CMWT*PI/(2.*HALFSW)
   CDW=CDW*PI/(2.*HALFSW)
   CLWW=CLWW*PI/(2.*HALFSW)

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CMWWT=CMWWT*PI/(2.*HALFSW)
CDWW=CDWW*PI/(2.*HALFSW)
IF (CLWW .LE. 0.001) GO TO 67
CDWL2=CDWW/(CLWW*CLWW)
GO TO 68
67 CDWL2=0.
68 CONTINUE
WRITE (6,53)
53 FORMAT (1H,5X,'VORTEX',3X,'XV',8X,'YV',8X,'CP',8X,'CPW')
K1=0
JJ1=0
DO 60 I=1,NCS
IF (NW(2) .EQ. 0) GO TO 62
II=I+NCS
IF (NW(3) .NE. 0) GO TO 69
CHORD=CH(I)+CH(II)
GO TO 63
69 III=II+NCS
CHORD=CH(I)+CH(II)+CH(III)
GO TO 63
62 CHORD=CH(I)
63 CONTINUE
DO 61 J=1,NCW
JJ=JJ1+J
KK=K1+J
IF (NW(2) .EQ. 0) GO TO 64
IF (J .LE. NW(1)) GO TO 64
IF (J .GT. NW(2)) GO TO 59
LL=LPAN1+NW(2)*(I-1)+J-NW(1)
GO TO 65
59 LL=LPAN2+NW(3)*(I-1)+J-NW(2)
GO TO 65
64 LL=JJ
65 CONTINUE
XI=(XV(LL)-XLE(I))/CHORD
ETA=YV(LL)/HALFB
CPW=2.*GAMW(LL)*ALPC
61 WRITE (6,54) KK,XI,ETA,CP(LL),CPW
JJ1=(NCW-NW3)*I
K1=K1+NCW
60 CONTINUE
54 FORMAT (7X,I3,3X,4F10.5)
WRITE (6,30)
30 FORMAT(1H0,5X,4HY/SP,7X,2HCL,7X,2HCM,7X,2HCT,7X,3HCDI,6X,
*3HCLW,6X,3HCMW,6X,3HCDW)
DO 31 I=1,NCS
YE=YLE(I)/HALFB
31 WRITE(6,32) YE,CL(I),CM(I),CT(I),CD(I),X(4,I),X(7,I),X(6,I)
32 FORMAT (3X,8F9.5)
DO 80 I=1,NCS
AW(I)=X(4,I)*CH(I)/CREF

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      CA(I)=CL(I)*CH(I)/CREF
80  CONTINUE
      WRITE (6,81)
81  FORMAT (1H,5X,'JET - OFF SPAN LOADING',7X,'JET - ON SPAN LOADING
1')
      WRITE (6,82) (AW(I),CA(I),I=1,NCS)
82  FORMAT (1H,2X,F10.5,10X,F20.5)
      WRITE (6,33) CLT
33  FORMAT (1H, 'THE LIFT COEFFICIENT =',F10.5)
      WRITE (6,24) CDT
24  FORMAT (1H, 'TOTAL INDUCED DRAG COEFFICIENT =',F10.5)
      WRITE (6,35) CDCL2
35  FORMAT(1H, 'THE INDUCED DRAG PARAMETER =',F10.5)
      WRITE (6,42) CMT
42  FORMAT(1H, 'TOTAL PITCHING MOMENT COEFFICIENT =',F10.5)
      IF (IUSB .NE. 1) GO TO 157
      IF (DFJ .LE. 0.001) GO TO 157
      IF (ZJET .GT. 0.01) GO TO 157
      SDFJ=SIN(DFJ)
      CDFJ=COS(DFJ)
      CLR=CMU*SIN(DFJ+ALP)
      CDR=CMU*(VMU-COS(DFJ+ALP))
      CF=COS(TDF)
      SF=SIN(TDF)
      IF (NNJ .EQ. 1) CDR=-CMU*COS(DFJ+ALP)
      IJ=(NSJ+1)/2-1
      IF (ISYM .EQ. 0) IJ=NSJ/2-1
      IF (NW(3) .NE. 0) GO TO 156
      IF (NW(2) .EQ. 0) GO TO 154
      IZ=NCS+(MJW1(2,NJP)-LPAN1-1)/NW(2)+1
      KJ=MJW1(2,NJP)
      NN=NW(2)
      GO TO 159
156  IZ=NCS*2+(MJW1(3,NJP)-LPAN2-1)/NW(3)+1
      KJ=MJW1(3,NJP)
      NN=NW(3)
      GO TO 159
154  IZ=LC(1)
      KJ=MJW1(1,NJP)
      NN=NW(1)
159  CONTINUE
      CM1=0.
      DO 158 I=1,IJ
      YDIF=YN(KJ,2)-YN(KJ,1)
      CM1=CM1+YDIF/WIDTH(NJW(NJP))*((XLE(IZ)+CH(IZ)*CF)*SDFJ-CH(IZ)*SF*C
1DFJ)
      KJ=KJ+NN
158  IZ=IZ+1
      CMR=-CM1*CMU/CREF
      IF (NNJ .NE. 1) WRITE (6,43) CLR
43  FORMAT (1H, 'THE COANDA LIFT COEFFICIENT, CLR=',F10.5)

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      IF (NNJ .EQ. 1) WRITE (6,47) CLR
47  FORMAT (1H0,47HTHE LIFT COEFFICIENT DUE TO JET REACTION, CLJ =,F10
1.5)
      IF (NNJ .NE. 1) WRITE (6,44) CDR
44  FORMAT (1H , 'THE COANDA DRAG COEFFICIENT, CDR=',F10.5)
      IF (NNJ .EQ. 1) WRITE (6,48) CDR
48  FORMAT (1H0,47HTHE DRAG COEFFICIENT DUE TO JET REACTION, CDJ =,F10
1.5)
      IF (NNJ .NE. 1) WRITE (6,45) CMR
45  FORMAT (1H , 'THE COANDA MOMENT COEFFICIENT, CMR = ',F10.5)
      IF (NNJ .EQ. 1) WRITE (6,49) CMR
49  FORMAT (1H0,58HTHE PITCHING MOMENT COEFFICIENT DUE TO JET REACTION
1, CMJ =,F10.5)
157 CONTINUE
      IF (IUSB .EQ. 1) GO TO 171
      WRITE (6,5) CLW
      WRITE (6,6) CDW
      WRITE (6,7) CMWT
171 CONTINUE
      5 FORMAT(1H0,2X,49HTHE LIFT COEFFICIENT WITH JET ENTRAINMENT ALONE =
1,F10.5)
      6 FORMAT(1H0,2X,57HTHE INDUCED DRAG COEFFICIENT WITH JET ENTRAINMENT
1 ALONE =,F10.5)
      7 FORMAT(1H0,2X,60HTHE PITCHING MOMENT COEFFICIENT WITH JET ENTRAINM
1ENT ALONE =,F10.5)
      WRITE (6,70) CLWW
70  FORMAT(1H , 'THE LIFT COEFFICIENT FOR THE WING ALONE =',F10.5)
      WRITE (6,71) CDWW
71  FORMAT(1H , 'THE INDUCED DRAG COEFFICIENT FOR THE WING ALONE =',
1F10.5)
      WRITE (6,72) CMWWT
72  FORMAT (1H , 'THE PITCHING MOMENT COEFFICIENT FOR THE WING ALONE' =
1',F10.5)
      WRITE (6,73) CDWL2
73  FORMAT(1H , 'THE INDUCED DRAG PARAMETER FOR THE WING ALONE =',
1F10.5)
      RETURN
      END

```

Sample Output

WING ALONE CASE

1 1 1 1

INPUT DATA

0.	0.	0.25760	1.00000	0.	-0.29391	0.12318
0.36364	0.	0.	-0.29391	0.25945	0.05000	1.00000
0.	1.00000	1.00000				0.37495
1.67600	10.00000	0.				
-0.56776	-0.09304	0.	0.48778	0.74033	1.00000	
-0.56776	-0.09304	0.	0.			
-0.56776	-0.09304	0.	0.10000			
0.48778	0.74033	1.00000	0.10000			
0.48778	0.74033	1.00000	0.			

HALF SW= 0.36364E 00

CREF= 0.37495E 00

LPANEL= 60 JPANEL= 48 LAST=108 LTOTAL=156

VORTEX ELEMENT ENDPOINT COORDINATES=

X1	X2	Y1	Y2	Z1	Z2
-0.55967	-0.51215	0.	0.04518	0.	0.
-0.49824	-0.45202	0.	0.04518	0.	0.
-0.39183	-0.34786	0.	0.04518	0.	0.
-0.26897	-0.22759	0.	0.04518	0.	0.
-0.16256	-0.12344	0.	0.04518	0.	0.
-0.10113	-0.06330	0.	0.04518	0.	0.
-0.51215	-0.43123	0.04518	0.12213	0.	0.
-0.45202	-0.37330	0.04518	0.12213	0.	0.
-0.34786	-0.27298	0.04518	0.12213	0.	0.
-0.22759	-0.15714	0.04518	0.12213	0.	0.
-0.12344	-0.05681	0.04518	0.12213	0.	0.
-0.06330	0.00111	0.04518	0.12213	0.	0.
-0.43123	-0.31811	0.12213	0.22968	0.	0.
-0.37330	-0.26328	0.12213	0.22968	0.	0.
-0.27298	-0.16831	0.12213	0.22968	0.	0.
-0.15714	-0.05865	0.12213	0.22968	0.	0.
-0.05681	0.03632	0.12213	0.22968	0.	0.
0.00111	0.09115	0.12213	0.22968	0.	0.
-0.31811	-0.18195	0.22968	0.35913	0.	0.
-0.26328	-0.13084	0.22968	0.35913	0.	0.
-0.16831	-0.04232	0.22968	0.35913	0.	0.
-0.05865	0.05989	0.22968	0.35913	0.	0.
0.03632	0.14841	0.22968	0.35913	0.	0.
0.09115	0.19952	0.22968	0.35913	0.	0.
-0.18195	-0.03379	0.35913	0.50000	0.	0.
-0.13084	0.01326	0.35913	0.50000	0.	0.
-0.04232	0.09477	0.35913	0.50000	0.	0.
0.05989	0.18889	0.35913	0.50000	0.	0.
0.14841	0.27039	0.35913	0.50000	0.	0.
0.19952	0.31745	0.35913	0.50000	0.	0.
-0.03379	0.11436	0.50000	0.64087	0.	0.

0.01326	0.15737	0.50000	0.64087	0.	0.
0.09477	0.23186	0.50000	0.64087	0.	0.
0.18889	0.31788	0.50000	0.64087	0.	0.
0.27039	0.39237	0.50000	0.64087	0.	0.
0.31745	0.43538	0.50000	0.64087	0.	0.
0.11436	0.25052	0.64087	0.77032	0.	0.
0.15737	0.28980	0.64087	0.77032	0.	0.
0.23186	0.35785	0.64087	0.77032	0.	0.
0.31788	0.43642	0.64087	0.77032	0.	0.
0.39237	0.50446	0.64087	0.77032	0.	0.
0.43538	0.54375	0.64087	0.77032	0.	0.
0.25052	0.36364	0.77032	0.87787	0.	0.
0.28980	0.39983	0.77032	0.87787	0.	0.
0.35785	0.46252	0.77032	0.87787	0.	0.
0.43642	0.53491	0.77032	0.87787	0.	0.
0.50446	0.59760	0.77032	0.87787	0.	0.
0.54375	0.63379	0.77032	0.87787	0.	0.
0.36364	0.44456	0.87787	0.95482	0.	0.
0.39983	0.47854	0.87787	0.95482	0.	0.
0.46252	0.53740	0.87787	0.95482	0.	0.
0.53491	0.60536	0.87787	0.95482	0.	0.
0.59760	0.66422	0.87787	0.95482	0.	0.
0.63379	0.69820	0.87787	0.95482	0.	0.
0.44456	0.48673	0.95482	0.99491	0.	0.
0.47854	0.51956	0.95482	0.99491	0.	0.
0.53740	0.57642	0.95482	0.99491	0.	0.
0.60536	0.64208	0.95482	0.99491	0.	0.
0.66422	0.69894	0.95482	0.99491	0.	0.
0.69820	0.73177	0.95482	0.99491	0.	0.
-0.55967	-0.55967	0.	0.	0.	0.10000
-0.49824	-0.49824	0.	0.	0.	0.10000
-0.39183	-0.39183	0.	0.	0.	0.10000
-0.26897	-0.26897	0.	0.	0.	0.10000
-0.16256	-0.16256	0.	0.	0.	0.10000
-0.10113	-0.10113	0.	0.	0.	0.10000
-0.55967	-0.23504	0.	0.30866	0.10000	0.10000
-0.49824	-0.18248	0.	0.30866	0.10000	0.10000
-0.39183	-0.09145	0.	0.30866	0.10000	0.10000
-0.26897	0.01367	0.	0.30866	0.10000	0.10000
-0.16256	0.10471	0.	0.30866	0.10000	0.10000
-0.10113	0.15727	0.	0.30866	0.10000	0.10000
-0.23504	0.16745	0.30866	0.69134	0.10000	0.10000
-0.18248	0.20901	0.30866	0.69134	0.10000	0.10000
-0.09145	0.28098	0.30866	0.69134	0.10000	0.10000
0.01367	0.36410	0.30866	0.69134	0.10000	0.10000
0.10471	0.43608	0.30866	0.69134	0.10000	0.10000
0.15727	0.47763	0.30866	0.69134	0.10000	0.10000
0.16745	0.49208	0.69134	1.00000	0.10000	0.10000
0.20901	0.52477	0.69134	1.00000	0.10000	0.10000
0.28098	0.58137	0.69134	1.00000	0.10000	0.10000
0.36410	0.64674	0.69134	1.00000	0.10000	0.10000
0.43608	0.70334	0.69134	1.00000	0.10000	0.10000
0.47763	0.73603	0.69134	1.00000	0.10000	0.10000
0.49208	0.49208	1.00000	1.00000	0.10000	0.
0.52477	0.52477	1.00000	1.00000	0.10000	0.
0.58137	0.58137	1.00000	1.00000	0.10000	0.
0.64674	0.64674	1.00000	1.00000	0.10000	0.
0.70334	0.70334	1.00000	1.00000	0.10000	0.
0.73603	0.73603	1.00000	1.00000	0.10000	0.
-0.55967	-0.23504	0.	0.30866	0.	0.

-0.49824	-0.18248	0.	0.30866	0.	0.
-0.39183	-0.09145	0.	0.30866	0.	0.
-0.26897	0.01367	0.	0.30866	0.	0.
-0.16256	0.10471	0.	0.30866	0.	0.
-0.10113	0.15727	0.	0.30866	0.	0.
-0.23504	0.16745	0.30866	0.69134	0.	0.
-0.18248	0.20901	0.30866	0.69134	0.	0.
-0.09145	0.28098	0.30866	0.69134	0.	0.
0.01367	0.36410	0.30866	0.69134	0.	0.
0.10471	0.43608	0.30866	0.69134	0.	0.
0.15727	0.47763	0.30866	0.69134	0.	0.
0.16745	0.49208	0.69134	1.00000	0.	0.
0.20901	0.52477	0.69134	1.00000	0.	0.
0.28098	0.58137	0.69134	1.00000	0.	0.
0.36410	0.64674	0.69134	1.00000	0.	0.
0.43608	0.70334	0.69134	1.00000	0.	0.
0.47763	0.73603	0.69134	1.00000	0.	0.

CONTROL POINT COORDINATES=

XCP	YCP	ZCP	XCP	YCP	ZCP
-0.51488	0.02025	0.	-0.42883	0.02025	0.
-0.31127	0.02025	0.	-0.19372	0.02025	0.
-0.10766	0.02025	0.	-0.07616	0.02025	0.
-0.45336	0.07937	0.	-0.36971	0.07937	0.
-0.25544	0.07937	0.	-0.14116	0.07937	0.
-0.05751	0.07937	0.	-0.02689	0.07937	0.
-0.35637	0.17257	0.	-0.27651	0.17257	0.
-0.16742	0.17257	0.	-0.05832	0.17257	0.
0.02154	0.17257	0.	0.05077	0.17257	0.
-0.23178	0.29229	0.	-0.15679	0.29229	0.
-0.05434	0.29229	0.	0.04810	0.29229	0.
0.12310	0.29229	0.	0.15055	0.29229	0.
-0.08968	0.42884	0.	-0.02024	0.42884	0.
0.07462	0.42884	0.	0.16948	0.42884	0.
0.23893	0.42884	0.	0.26434	0.42884	0.
0.05842	0.57116	0.	0.12208	0.57116	0.
0.20903	0.57116	0.	0.29599	0.57116	0.
0.35965	0.57116	0.	0.38295	0.57116	0.
0.20052	0.70771	0.	0.25863	0.70771	0.
0.33800	0.70771	0.	0.41737	0.70771	0.
0.47547	0.70771	0.	0.49674	0.70771	0.
0.32511	0.82743	0.	0.37835	0.82743	0.
0.45107	0.82743	0.	0.52379	0.82743	0.
0.57703	0.82743	0.	0.59652	0.82743	0.
0.42210	0.92063	0.	0.47154	0.92063	0.
0.53909	0.92063	0.	0.60664	0.92063	0.
0.65608	0.92063	0.	0.67418	0.92063	0.
0.48362	0.97975	0.	0.53066	0.97975	0.
0.59493	0.97975	0.	0.65919	0.97975	0.
0.70623	0.97975	0.	0.72345	0.97975	0.
-0.53596	0.	0.05000	-0.44908	0.	0.05000
-0.33040	0.	0.05000	-0.21172	0.	0.05000
-0.12484	0.	0.05000	-0.09304	0.	0.05000
-0.38356	0.14645	0.10000	-0.30263	0.14645	0.10000
-0.19209	0.14645	0.10000	-0.08154	0.14645	0.10000
-0.00062	0.14645	0.10000	0.02900	0.14645	0.10000
-0.01563	0.50000	0.10000	0.05092	0.50000	0.10000
0.14183	0.50000	0.10000	0.23274	0.50000	0.10000
0.29929	0.50000	0.10000	0.32364	0.50000	0.10000

0.35230	0.85355	0.10000	0.40447	0.85355	0.10000
0.47574	0.85355	0.10000	0.54701	0.85355	0.10000
0.59919	0.85355	0.10000	0.61829	0.85355	0.10000
0.50470	1.00000	0.05000	0.55092	1.00000	0.05000
0.61406	1.00000	0.05000	0.67719	1.00000	0.05000
0.72341	1.00000	0.05000	0.74033	1.00000	0.05000
-0.38356	0.14645	0.	-0.30263	0.14645	0.
-0.19209	0.14645	0.	-0.08154	0.14645	0.
-0.00062	0.14645	0.	0.02900	0.14645	0.
-0.01563	0.50000	0.	0.05092	0.50000	0.
0.14183	0.50000	0.	0.23274	0.50000	0.
0.29929	0.50000	0.	0.32364	0.50000	0.
0.35230	0.85355	0.	0.40447	0.85355	0.
0.47574	0.85355	0.	0.54701	0.85355	0.
0.59919	0.85355	0.	0.61829	0.85355	0.

CDBAR,CLBAR,CMBAR,DELTA,MAXP

0.02084	0.60000	-0.03600	50.00000	15
THE COMPUTED STEP SIZE, DELTA= 50.000 AT 1TH ITERATION				
INDUCED DRAG COEFFICIENT, CDII=		0.03282		
LIFT COEFFICIENT, CLII=		0.60000		
PITCHING MOMENT COEFFICIENT,CMII=		-0.03600		
THE COMPUTED STEP SIZE, DELTA= 9.174 AT 2TH ITERATION				
INDUCED DRAG COEFFICIENT, CDII=		0.02461		
LIFT COEFFICIENT, CLII=		0.60000		
PITCHING MOMENT COEFFICIENT,CMII=		-0.03600		
THE COMPUTED STEP SIZE, DELTA= 1.670 AT 3TH ITERATION				
INDUCED DRAG COEFFICIENT, CDII=		0.02420		
LIFT COEFFICIENT, CLII=		0.60000		
PITCHING MOMENT COEFFICIENT,CMII=		-0.03600		
THE COMPUTED STEP SIZE, DELTA= 10.489 AT 4TH ITERATION				
INDUCED DRAG COEFFICIENT, CDII=		0.02326		
LIFT COEFFICIENT, CLII=		0.60000		
PITCHING MOMENT COEFFICIENT,CMII=		-0.03600		
THE COMPUTED STEP SIZE, DELTA= 5.512 AT 5TH ITERATION				
INDUCED DRAG COEFFICIENT, CDII=		0.02296		
LIFT COEFFICIENT, CLII=		0.60000		
PITCHING MOMENT COEFFICIENT,CMII=		-0.03600		
THE COMPUTED STEP SIZE, DELTA= 9.641 AT 6TH ITERATION				
INDUCED DRAG COEFFICIENT, CDII=		0.02277		
LIFT COEFFICIENT, CLII=		0.60000		
PITCHING MOMENT COEFFICIENT,CMII=		-0.03600		
THE COMPUTED STEP SIZE, DELTA= 15.344 AT 7TH ITERATION				
INDUCED DRAG COEFFICIENT, CDII=		0.02258		
LIFT COEFFICIENT, CLII=		0.60000		
PITCHING MOMENT COEFFICIENT,CMII=		-0.03600		
THE COMPUTED STEP SIZE, DELTA= 4.746 AT 8TH ITERATION				
INDUCED DRAG COEFFICIENT, CDII=		0.02252		
LIFT COEFFICIENT, CLII=		0.60000		
PITCHING MOMENT COEFFICIENT,CMII=		-0.03600		
THE COMPUTED STEP SIZE, DELTA= 215.245 AT 9TH ITERATION				
INDUCED DRAG COEFFICIENT, CDII=		0.02148		
LIFT COEFFICIENT, CLII=		0.60000		
PITCHING MOMENT COEFFICIENT,CMII=		-0.03600		
THE TWIST DISTRIBUTION IN THE SPANWISE DIRECTION				

YLE(1)=	0.02025	ALPA0(1)=	19.93581
YLE(2)=	0.07937	ALPA0(2)=	2.04388
YLE(3)=	0.17257	ALPA0(3)=	6.30106
YLE(4)=	0.29229	ALPA0(4)=	5.59977
YLE(5)=	0.42884	ALPA0(5)=	4.20544
YLE(6)=	0.57116	ALPA0(6)=	3.00911

YLE(7)=	0.70771	ALPA0(7)=	1.90836
YLE(8)=	0.82743	ALPA0(8)=	0.94083
YLE(9)=	0.92063	ALPA0(9)=	0.24668
YLE(10)=	0.97975	ALPA0(10)=	-0.78169

THE CAMBER ORDINATES IN THE WING ALONE CASE

0.00887	0.06269	0.09079	0.05172	0.00993	0.00003
0.00516	0.03465	0.06392	0.06067	0.02714	0.00328
0.00824	0.04995	0.06767	0.04448	0.01431	0.00140
0.00921	0.05673	0.07562	0.04872	0.01569	0.00139
0.00895	0.05666	0.07750	0.05047	0.01616	0.00137
0.00817	0.05342	0.07682	0.05268	0.01785	0.00162
0.00713	0.04825	0.07367	0.05439	0.02019	0.00202
0.00597	0.04197	0.06835	0.05490	0.02258	0.00248
0.00478	0.03515	0.06156	0.05456	0.02507	0.00296
0.00337	0.02655	0.05037	0.04884	0.02478	0.00313

OPTIMUM PRESSURE LOADING IN THE WING ALONE CASE

0.33925	0.95849	1.10169	0.64982	0.13565	-0.03151
0.30567	0.68236	0.90372	0.75224	0.33858	0.10925
0.49081	1.01350	0.95480	0.56554	0.17322	0.03985
0.52897	1.12571	0.98873	0.52540	0.13808	0.00525
0.49336	1.09702	0.99172	0.52162	0.12412	-0.00885
0.42952	0.99758	0.96347	0.54116	0.14645	0.00098
0.35511	0.86232	0.90144	0.56180	0.19145	0.02388
0.27805	0.70889	0.80097	0.55686	0.23455	0.04755
0.19747	0.53467	0.63793	0.48581	0.24292	0.05915
0.11020	0.30103	0.34792	0.28153	0.17088	0.04799

JET ON CASE WITH UPPER SURFACE BLOWING

INPUT DATA

0.	0.	0.25760	1.00000	0.	-0.29391	0.12318
1	1	0.				
0.36364	0.	0.	-0.29391	0.25945	0.05000	1.00000 0.37495
0.	1.00000	1.00000				
1.67600	10.00000	0.				
3	3	4	6			
2						
6	0	0				
-0.56776	-0.09304	0.	-0.36750	0.06507	0.18972	
-0.36750	0.06507	0.18972	-0.22031	0.18128	0.32917	
-0.22031	0.18128	0.32917	0.48778	0.74033	1.00000	
2	7	6	4			
-0.36750	0.06507	0.18972	0.			
-0.36750	0.06507	0.18972	0.10000			
-0.22031	0.18128	0.32917	0.10000			
-0.22031	0.18128	0.32917	0.			
0.06507	0.49764	0.18972	0.			
0.06507	0.49764	0.18972	0.10000			
0.18128	0.58287	0.32917	0.10000			
0.18128	0.58287	0.32917	0.			

HALF SL= 0.36364E C0 CREF= 0.37495E 00

LPANEL= 60 JPANEL= 80 LAST=140 LTOTAL=220

VORTEX ELEMENT ENDPPOINT COORDINATES=

X1	X2	Y1	Y2	Z1	Z2
-0.55967	-0.45990	0.	0.09486	0.	0.
-0.49824	-0.40120	0.	0.09486	0.	0.

-0.39183	-0.29951	0.	0.09486	0.	0.
-0.26897	-0.18210	0.	0.09486	0.	0.
-0.16256	-0.08042	0.	0.09486	0.	0.
-0.10113	-0.02171	0.	0.09486	0.	0.
-0.45990	-0.36013	0.09486	0.18972	0.	0.
-0.40120	-0.30415	0.09486	0.18972	0.	0.
-0.29951	-0.20719	0.09486	0.18972	0.	0.
-0.18210	-0.09524	0.09486	0.18972	0.	0.
-0.08042	0.00172	0.09486	0.18972	0.	0.
-0.02171	0.05770	0.09486	0.18972	0.	0.
-0.36013	-0.31486	0.18972	0.23276	0.	0.
-0.30415	-0.26012	0.18972	0.23276	0.	0.
-0.20719	-0.16531	0.18972	0.23276	0.	0.
-0.09524	-0.05582	0.18972	0.23276	0.	0.
0.00172	0.03899	0.18972	0.23276	0.	0.
0.05770	0.09373	0.18972	0.23276	0.	0.
-0.31486	-0.25874	0.23276	0.28613	0.	0.
-0.26012	-0.20553	0.23276	0.28613	0.	0.
-0.16531	-0.11337	0.23276	0.28613	0.	0.
-0.05582	-0.00696	0.23276	0.28613	0.	0.
0.03899	0.08520	0.23276	0.28613	0.	0.
0.09373	0.13841	0.23276	0.28613	0.	0.
-0.25874	-0.21347	0.28613	0.32917	0.	0.
-0.20553	-0.16150	0.28613	0.32917	0.	0.
-0.11337	-0.07148	0.28613	0.32917	0.	0.
-0.00696	0.03245	0.28613	0.32917	0.	0.
0.08520	0.12247	0.28613	0.32917	0.	0.
0.13841	0.17444	0.28613	0.32917	0.	0.
-0.21347	-0.11014	0.32917	0.42741	0.	0.
-0.16150	-0.06100	0.32917	0.42741	0.	0.
-0.07148	0.02412	0.32917	0.42741	0.	0.
0.03245	0.12241	0.32917	0.42741	0.	0.
0.12247	0.20754	0.32917	0.42741	0.	0.
0.17444	0.25668	0.32917	0.42741	0.	0.
-0.11014	0.04800	0.42741	0.57777	0.	0.
-0.06100	0.09282	0.42741	0.57777	0.	0.
0.02412	0.17046	0.42741	0.57777	0.	0.
0.12241	0.26010	0.42741	0.57777	0.	0.
0.20754	0.33774	0.42741	0.57777	0.	0.
0.25668	0.38256	0.42741	0.57777	0.	0.
0.04800	0.23061	0.57777	0.75140	0.	0.
0.09282	0.27044	0.57777	0.75140	0.	0.
0.17046	0.33943	0.57777	0.75140	0.	0.
0.26010	0.41909	0.57777	0.75140	0.	0.
0.33774	0.48808	0.57777	0.75140	0.	0.
0.38256	0.52791	0.57777	0.75140	0.	0.
0.23061	0.38876	0.75140	0.90176	0.	0.
0.27044	0.42426	0.75140	0.90176	0.	0.
0.33943	0.48576	0.75140	0.90176	0.	0.
0.41909	0.55678	0.75140	0.90176	0.	0.
0.48808	0.61828	0.75140	0.90176	0.	0.
0.52791	0.65378	0.75140	0.90176	0.	0.
0.38876	0.48006	0.90176	0.98857	0.	0.
0.42426	0.51307	0.90176	0.98857	0.	0.
0.48576	0.57025	0.90176	0.98857	0.	0.
0.55678	0.63627	0.90176	0.98857	0.	0.
0.61828	0.69345	0.90176	0.98857	0.	0.
0.65378	0.72646	0.90176	0.98857	0.	0.
-0.36013	-0.36013	0.18972	0.18972	0.	0.10000
-0.30415	-0.30415	0.18972	0.18972	0.	0.10000

-0.20719	-0.20719	0.18972	0.18972	0.	0.10000
-0.09524	-0.09524	0.18972	0.18972	0.	0.10000
0.00172	0.00172	0.18972	0.18972	0.	0.10000
0.05770	0.05770	0.18972	0.18972	0.	0.10000
-0.36013	-0.31486	0.18972	0.23276	0.10000	0.10000
-0.30415	-0.26012	0.18972	0.23276	0.10000	0.10000
-0.20719	-0.16531	0.18972	0.23276	0.10000	0.10000
-0.09524	-0.05582	0.18972	0.23276	0.10000	0.10000
0.00172	0.03899	0.18972	0.23276	0.10000	0.10000
0.05770	0.09373	0.18972	0.23276	0.10000	0.10000
-0.31486	-0.25874	0.23276	0.28613	0.10000	0.10000
-0.26012	-0.20553	0.23276	0.28613	0.10000	0.10000
-0.16531	-0.11337	0.23276	0.28613	0.10000	0.10000
-0.05582	-0.00696	0.23276	0.28613	0.10000	0.10000
0.03899	0.08520	0.23276	0.28613	0.10000	0.10000
0.09373	0.13841	0.23276	0.28613	0.10000	0.10000
-0.25874	-0.21347	0.28613	0.32917	0.10000	0.10000
-0.20553	-0.16150	0.28613	0.32917	0.10000	0.10000
-0.11337	-0.07148	0.28613	0.32917	0.10000	0.10000
-0.00696	0.03245	0.28613	0.32917	0.10000	0.10000
0.08520	0.12247	0.28613	0.32917	0.10000	0.10000
0.13841	0.17444	0.28613	0.32917	0.10000	0.10000
-0.21347	-0.21347	0.32917	0.32917	0.10000	0.
-0.16150	-0.16150	0.32917	0.32917	0.10000	0.
-0.07148	-0.07148	0.32917	0.32917	0.10000	0.
0.03245	0.03245	0.32917	0.32917	0.10000	0.
0.12247	0.12247	0.32917	0.32917	0.10000	0.
0.17444	0.17444	0.32917	0.32917	0.10000	0.
-0.36013	-0.31486	0.18972	0.23276	0.	0.
-0.30415	-0.26012	0.18972	0.23276	0.	0.
-0.20719	-0.16531	0.18972	0.23276	0.	0.
-0.09524	-0.05582	0.18972	0.23276	0.	0.
0.00172	0.03899	0.18972	0.23276	0.	0.
0.05770	0.09373	0.18972	0.23276	0.	0.
-0.31486	-0.25874	0.23276	0.28613	0.	0.
-0.26012	-0.20553	0.23276	0.28613	0.	0.
-0.16531	-0.11337	0.23276	0.28613	0.	0.
-0.05582	-0.00696	0.23276	0.28613	0.	0.
0.03899	0.08520	0.23276	0.28613	0.	0.
0.09373	0.13841	0.23276	0.28613	0.	0.
-0.25874	-0.21347	0.28613	0.32917	0.	0.
-0.20553	-0.16150	0.28613	0.32917	0.	0.
-0.11337	-0.07148	0.28613	0.32917	0.	0.
-0.00696	0.03245	0.28613	0.32917	0.	0.
0.08520	0.12247	0.28613	0.32917	0.	0.
0.13841	0.17444	0.28613	0.32917	0.	0.
0.08153	0.08153	0.18972	0.18972	0.	0.10000
0.19859	0.19859	0.18972	0.18972	0.	0.10000
0.36412	0.36412	0.18972	0.18972	0.	0.10000
0.48118	0.48118	0.18972	0.18972	0.	0.10000
0.08153	0.11704	0.18972	0.23276	0.10000	0.10000
0.19859	0.23150	0.18972	0.23276	0.10000	0.10000
0.36412	0.39338	0.18972	0.23276	0.10000	0.10000
0.48118	0.50785	0.18972	0.23276	0.10000	0.10000
0.11704	0.16106	0.23276	0.28613	0.10000	0.10000
0.23150	0.27232	0.23276	0.28613	0.10000	0.10000
0.39338	0.42966	0.23276	0.28613	0.10000	0.10000
0.50785	0.54091	0.23276	0.28613	0.10000	0.10000
0.16106	0.19656	0.28613	0.32917	0.10000	0.10000
0.27232	0.30523	0.28613	0.32917	0.10000	0.10000

0.42966	0.45892	0.28613	0.32917	0.10000	0.10000
0.54091	0.56759	0.28613	0.32917	0.10000	0.10000
0.19656	0.19656	0.32917	0.32917	0.10000	0.
0.30523	0.30523	0.32917	0.32917	0.10000	0.
0.45892	0.45892	0.32917	0.32917	0.10000	0.
0.56759	0.56759	0.32917	0.32917	0.10000	0.
0.08153	0.11704	0.18972	0.23276	0.	0.
0.19859	0.23150	0.18972	0.23276	0.	0.
0.36412	0.39338	0.18972	0.23276	0.	0.
0.48118	0.50785	0.18972	0.23276	0.	0.
0.11704	0.16106	0.23276	0.28613	0.	0.
0.23150	0.27232	0.23276	0.28613	0.	0.
0.39338	0.42966	0.23276	0.28613	0.	0.
0.50785	0.54091	0.23276	0.28613	0.	0.
0.16106	0.19656	0.28613	0.32917	0.	0.
0.27232	0.30523	0.28613	0.32917	0.	0.
0.42966	0.45892	0.28613	0.32917	0.	0.
0.54091	0.56759	0.28613	0.32917	0.	0.

CONTROL POINT COORDINATES=

XCP	YCP	ZCP	XCP	YCP	ZCP
-0.48660	0.04743	0.	-0.40165	0.04743	0.
-0.28560	0.04743	0.	-0.16956	0.04743	0.
-0.08461	0.04743	0.	-0.05351	0.04743	0.
-0.38788	0.14229	0.	-0.30679	0.14229	0.
-0.19601	0.14229	0.	-0.08523	0.14229	0.
-0.00414	0.14229	0.	0.02554	0.14229	0.
-0.31727	0.21014	0.	-0.23894	0.21014	0.
-0.13193	0.21014	0.	-0.02492	0.21014	0.
0.05342	0.21014	0.	0.08209	0.21014	0.
-0.26597	0.25944	0.	-0.18964	0.25944	0.
-0.08537	0.25944	0.	0.01890	0.25944	0.
0.09524	0.25944	0.	0.12317	0.25944	0.
-0.21466	0.30875	0.	-0.14033	0.30875	0.
-0.03880	0.30875	0.	0.06273	0.30875	0.
0.13706	0.30875	0.	0.16426	0.30875	0.
-0.14664	0.37411	0.	-0.07498	0.37411	0.
0.02293	0.37411	0.	0.12083	0.37411	0.
0.19250	0.37411	0.	0.21873	0.37411	0.
-0.01888	0.49688	0.	0.04779	0.49688	0.
0.13888	0.49688	0.	0.22996	0.49688	0.
0.29664	0.49688	0.	0.32104	0.49688	0.
0.15564	0.66458	0.	0.21550	0.66458	0.
0.29727	0.66458	0.	0.37904	0.66458	0.
0.43890	0.66458	0.	0.46080	0.66458	0.
0.33017	0.83229	0.	0.38321	0.83229	0.
0.45566	0.83229	0.	0.52811	0.83229	0.
0.58115	0.83229	0.	0.60057	0.83229	0.
0.45793	0.95506	0.	0.50598	0.95506	0.
0.57161	0.95506	0.	0.63725	0.95506	0.
0.68529	0.95506	0.	0.70288	0.95506	0.
-0.33852	0.18972	0.05000	-0.25936	0.18972	0.05000
-0.15122	0.18972	0.05000	-0.04307	0.18972	0.05000
0.03609	0.18972	0.05000	0.06507	0.18972	0.05000
-0.31727	0.21014	0.10000	-0.23894	0.21014	0.10000
-0.13193	0.21014	0.10000	-0.02492	0.21014	0.10000
0.05342	0.21014	0.10000	0.08209	0.21014	0.10000
-0.26597	0.25944	0.10000	-0.18964	0.25944	0.10000
-0.08537	0.25944	0.10000	0.01890	0.25944	0.10000

0.09524	0.25944	0.10000	0.12317	0.25944	0.10000
-0.21466	0.30875	0.10000	-0.14033	0.30875	0.10000
-0.03880	0.30875	0.10000	0.06273	0.30875	0.10000
0.13706	0.30875	0.10000	0.16426	0.30875	0.10000
-0.19341	0.32917	0.05000	-0.11991	0.32917	0.05000
-0.01952	0.32917	0.05000	0.08088	0.32917	0.05000
0.15438	0.32917	0.05000	0.18128	0.32917	0.05000
-0.31727	0.21014	0.	-0.23894	0.21014	0.
-0.13193	0.21014	0.	-0.02492	0.21014	0.
0.05342	0.21014	0.	0.08209	0.21014	0.
-0.26597	0.25944	0.	-0.18964	0.25944	0.
-0.08537	0.25944	0.	0.01890	0.25944	0.
0.09524	0.25944	0.	0.12317	0.25944	0.
-0.21466	0.30875	0.	-0.14033	0.30875	0.
-0.03880	0.30875	0.	0.06273	0.30875	0.
0.13706	0.30875	0.	0.16426	0.30875	0.
0.12842	0.18972	0.05000	0.28135	0.18972	0.05000
0.43429	0.18972	0.05000	0.49764	0.18972	0.05000
0.14477	0.21014	0.10000	0.29611	0.21014	0.10000
0.44744	0.21014	0.10000	0.51012	0.21014	0.10000
0.18425	0.25944	0.10000	0.33171	0.25944	0.10000
0.47918	0.25944	0.10000	0.54026	0.25944	0.10000
0.22374	0.30875	0.10000	0.36732	0.30875	0.10000
0.51091	0.30875	0.10000	0.57039	0.30875	0.10000
0.24009	0.32917	0.05000	0.38207	0.32917	0.05000
0.52406	0.32917	0.05000	0.58287	0.32917	0.05000
0.14477	0.21014	0.	0.29611	0.21014	0.
0.44744	0.21014	0.	0.51012	0.21014	0.
0.18425	0.25944	0.	0.33171	0.25944	0.
0.47918	0.25944	0.	0.54026	0.25944	0.
0.22374	0.30875	0.	0.36732	0.30875	0.
0.51091	0.30875	0.	0.57039	0.30875	0.

CLII, CMII, DELTA, MAXP

1.20000 -0.07500 0.10000 20

NUMB, SIZE

5 0.40000

INDUCED DRAG COEFFICIENT, CDII= 0.02932

LIFT COEFFICIENT, CLII= 0.88280

PITCHING MOMENT COEFFICIENT, CMII= 0.06624

THE TWIST DISTRIBUTION IN THE SPANWISE DIRECTION

YLE(1)= 0.04743 ALPA0(1)= 6.37815

YLE(2)= 0.14229 ALPA0(2)= 4.85762

YLE(3)= 0.21014 ALPA0(3)= 6.91677

YLE(4)= 0.25944 ALPA0(4)= 6.30695

YLE(5)= 0.30875 ALPA0(5)= 5.26961

YLE(6)= 0.37411 ALPA0(6)= 4.44399

YLE(7)= 0.49688 ALPA0(7)= 3.82860

YLE(8)= 0.66458 ALPA0(8)= 2.11882

YLE(9)= 0.83229 ALPA0(9)= 0.88134

YLE(10)= 0.95506 ALPA0(10)= 0.05737

CAMBER ORDINATES IN THE JET ON CASE

0.00564 0.04024 0.07250 0.06315 0.02568 0.00281

0.00730 0.04475 0.06478 0.04747 0.01730 0.00190

0.00892 0.05413 0.07107 0.04421 0.01331 0.00118

0.00921 0.05636 0.07428 0.04682 0.01456 0.00127

0.00918 0.05677 0.07610 0.04947 0.01612 0.00143

0.00906 0.05678 0.07718 0.05068 0.01660 0.00145

0.00868 0.05571 0.07745 0.05083 0.01629 0.00138

0.00745 0.04990 0.07499 0.05441 0.01977 0.00194

0.00591 0.04164 0.06808 0.05499 0.02276 0.00251

0.00416 0.03136 0.05646 0.05174 0.02481 0.00302

XX

ALPHA = 0. DEGREES

XX

VORTEX	XV	YV	CP	CPW
1	0.01704	0.04743	0.36369	0.27324
2	0.14645	0.04743	0.74771	0.69602
3	0.37059	0.04743	1.01748	0.95547
4	0.62941	0.04743	0.82461	0.76591
5	0.85355	0.04743	0.35414	0.31755
6	0.98296	0.04743	0.09244	0.08041
7	0.01704	0.14229	0.60472	0.44343
8	0.14645	0.14229	1.02375	0.91657
9	0.37059	0.14229	1.04341	0.93288
10	0.62941	0.14229	0.67637	0.61393
11	0.85355	0.14229	0.24634	0.21871
12	0.98296	0.14229	0.07384	0.06350
13	0.01704	0.21014	-0.07581	0.52313
14	0.14645	0.21014	5.09808	1.08728
15	0.37059	0.21014	4.10085	0.97367
16	0.62941	0.21014	1.51720	0.53386
17	0.85355	0.21014	-0.29706	0.14443
18	0.98296	0.21014	0.65598	0.02075
19	0.01704	0.25944	-0.20226	0.53314
20	0.14645	0.25944	5.58176	1.12298
21	0.37059	0.25944	4.15151	0.98545
22	0.62941	0.25944	1.33517	0.52403
23	0.85355	0.25944	-0.22270	0.13686
24	0.98296	0.25944	0.75326	0.00914
25	0.01704	0.30875	-0.54272	0.52548
26	0.14645	0.30875	5.29067	1.12427
27	0.37059	0.30875	4.12287	0.98979
28	0.62941	0.30875	1.62636	0.52630
29	0.85355	0.30875	-0.14901	0.13835
30	0.98296	0.30875	0.69648	0.00357
31	0.01704	0.37411	0.55533	0.50901
32	0.14645	0.37411	1.17755	1.11257
33	0.37059	0.37411	1.08933	0.99236
34	0.62941	0.37411	0.63420	0.52534
35	0.85355	0.37411	0.22314	0.13237
36	0.98296	0.37411	0.02890	-0.00368
37	0.01704	0.49688	0.63958	0.46737
38	0.14645	0.49688	1.13313	1.06074
39	0.37059	0.49688	1.04020	0.98344
40	0.62941	0.49688	0.56771	0.52471
41	0.85355	0.49688	0.15053	0.12542
42	0.98296	0.49688	-0.00061	-0.00870
43	0.01704	0.66458	0.54141	0.37828
44	0.14645	0.66458	0.96227	0.90573
45	0.37059	0.66458	0.95878	0.92505
46	0.62941	0.66458	0.58067	0.55977
47	0.85355	0.66458	0.19068	0.17927
48	0.98296	0.66458	0.02079	0.01716
49	0.01704	0.83229	0.40050	0.27428
50	0.14645	0.83229	0.74232	0.70117
51	0.37059	0.83229	0.81743	0.79535
52	0.62941	0.83229	0.56839	0.55616

53	0.85355	0.83229	0.24280	0.23663
54	0.98296	0.83229	0.05058	0.04868
55	0.01704	0.95506	0.24694	0.15589
56	0.14645	0.95506	0.45343	0.42816
57	0.37059	0.95506	0.51478	0.50533
58	0.62941	0.95506	0.39531	0.39131
59	0.85355	0.95506	0.21155	0.20976
60	0.98296	0.95506	0.05405	0.05351

Y/SP	CL	CM	CT	CDI	CLW	CMW	CDW
0.04743	0.70071	0.58443	0.	0.06288	0.64689	0.53890	0.05870
0.14229	0.71599	0.46915	0.	0.03353	0.63567	0.41331	0.03247
0.21014	2.34876	1.29871	0.	0.16684	0.64609	0.33297	0.04727
0.25944	2.41687	1.04057	0.	0.12010	0.65168	0.25603	0.03664
0.30875	2.41610	0.68023	0.	0.10127	0.65297	0.17240	0.02297
0.37411	0.73473	0.05386	0.	0.02235	0.64850	0.06084	0.01286
0.49688	0.68753	-0.15679	0.	0.00496	0.63204	-0.14489	0.00759
0.66458	0.64082	-0.43835	0.	-0.00905	0.60313	-0.41597	-0.00433
0.83229	0.56337	-0.64422	0.	-0.01178	0.53726	-0.61765	-0.00805
0.95506	0.37364	-0.55137	0.	-0.01011	0.35902	-0.53237	-0.00783

JET - OFF SPAN LOADING

0.80084

0.75122

0.73756

0.72490

0.70726

0.67731

0.61414

0.52611

0.41526

0.25138

JET - ON SPAN LOADING

0.86746

0.84614

2.68128

2.68843

2.61700

0.76737

0.66806

0.55899

0.43545

0.26162

THE LIFT COEFFICIENT = 0.88280

TOTAL INDUCED DRAG COEFFICIENT = 0.02932

THE INDUCED DRAG PARAMETER = 0.03762

TOTAL PITCHING MOMENT COEFFICIENT = 0.06624

THE COANDA LIFT COEFFICIENT, CLR= 0.29103

THE COANDA DRAG COEFFICIENT, CDR= -1.21880

THE COANDA MOMENT COEFFICIENT, CMR = -0.09561

THE LIFT COEFFICIENT FOR THE WING ALONE = 0.57709

THE INDUCED DRAG COEFFICIENT FOR THE WING ALONE = 0.01552

THE PITCHING MOMENT COEFFICIENT FOR THE WING ALONE = -0.04943

THE INDUCED DRAG PARAMETER FOR THE WING ALONE = 0.04659

DELTA= 0.100 1TH ITERATION OF 1TH INTERMEDIATE CYCLES

INDUCED DRAG COEFFICIENT, CDII= 0.04594

LIFT COEFFICIENT, CLII= 0.94622

PITCHING MOMENT COEFFICIENT, CMII= 0.03800

DELTA= 0.400 2TH ITERATION OF 1TH INTERMEDIATE CYCLES

INDUCED DRAG COEFFICIENT, CDII= 0.04055

LIFT COEFFICIENT, CLII= 0.94624

PITCHING MOMENT COEFFICIENT, CMII= 0.03800

DELTA= 0.100 1TH ITERATION OF 2TH INTERMEDIATE CYCLES

INDUCED DRAG COEFFICIENT, CDII= 0.05243

LIFT COEFFICIENT, CLII= 1.00966

PITCHING MOMENT COEFFICIENT, CMII= 0.00975

DELTA= 0.400 2TH ITERATION OF 2TH INTERMEDIATE CYCLES

INDUCED DRAG COEFFICIENT, CDII= 0.04604

LIFT COEFFICIENT, CLII= 1.00968
PITCHING MOMENT COEFFICIENT, CMII= 0.00975

DELTA= 0.100 1TH ITERATION OF 3TH INTERMEDIATE CYCLES

INDUCED DRAG COEFFICIENT, CDII= 0.05924
LIFT COEFFICIENT, CLII= 1.07310
PITCHING MOMENT COEFFICIENT, CMII= -0.01850

DELTA= 0.400 2TH ITERATION OF 3TH INTERMEDIATE CYCLES

INDUCED DRAG COEFFICIENT, CDII= 0.05167
LIFT COEFFICIENT, CLII= 1.07311
PITCHING MOMENT COEFFICIENT, CMII= -0.01850

DELTA= 0.100 1TH ITERATION OF 4TH INTERMEDIATE CYCLES

INDUCED DRAG COEFFICIENT, CDII= 0.06599
LIFT COEFFICIENT, CLII= 1.13654
PITCHING MOMENT COEFFICIENT, CMII= -0.04675

DELTA= 0.400 2TH ITERATION OF 4TH INTERMEDIATE CYCLES

INDUCED DRAG COEFFICIENT, CDII= 0.05725
LIFT COEFFICIENT, CLII= 1.13655
PITCHING MOMENT COEFFICIENT, CMII= -0.04675

DELTA= 0.100 1TH ITERATION OF 5TH INTERMEDIATE CYCLES

INDUCED DRAG COEFFICIENT, CDII= 0.07251
LIFT COEFFICIENT, CLII= 1.19998
PITCHING MOMENT COEFFICIENT, CMII= -0.07500

DELTA= 0.400 2TH ITERATION OF 5TH INTERMEDIATE CYCLES

INDUCED DRAG COEFFICIENT, CDII= 0.06263
LIFT COEFFICIENT, CLII= 1.19999
PITCHING MOMENT COEFFICIENT, CMII= -0.07500

THE 1TH ITERATION IN THE FINAL CYCLE, DELTA= 0.400

INDUCED DRAG COEFFICIENT, CDII= 0.05417
LIFT COEFFICIENT, CLII= 1.19999
PITCHING MOMENT COEFFICIENT, CMII= -0.07500

THE ROOT MEAN SQUARE OF CAMBER ORDINATES= 0.00075

THE 2TH ITERATION IN THE FINAL CYCLE, DELTA= 0.400

INDUCED DRAG COEFFICIENT, CDII= 0.04681
LIFT COEFFICIENT, CLII= 1.20000
PITCHING MOMENT COEFFICIENT, CMII= -0.07500

THE ROOT MEAN SQUARE OF CAMBER ORDINATES= 0.00068

THE 3TH ITERATION IN THE FINAL CYCLE, DELTA= 0.400

INDUCED DRAG COEFFICIENT, CDII= 0.04030
LIFT COEFFICIENT, CLII= 1.20000
PITCHING MOMENT COEFFICIENT, CMII= -0.07500

THE ROOT MEAN SQUARE OF CAMBER ORDINATES= 0.00062

THE 4TH ITERATION IN THE FINAL CYCLE, DELTA= 0.400

INDUCED DRAG COEFFICIENT, CDII= 0.03450
LIFT COEFFICIENT, CLII= 1.20000
PITCHING MOMENT COEFFICIENT, CMII= -0.07500

THE ROOT MEAN SQUARE OF CAMBER ORDINATES= 0.00057

THE 5TH ITERATION IN THE FINAL CYCLE, DELTA= 0.400

INDUCED DRAG COEFFICIENT, CDII= 0.02928
LIFT COEFFICIENT, CLII= 1.20000

PITCHING MOMENT COEFFICIENT, CMII= -0.07500
THE ROOT MEAN SQUARE OF CAMBER ORDINATES= 0.00053

THE 6TH ITERATION IN THE FINAL CYCLE, DELTA= 0.400
INDUCED DRAG COEFFICIENT, CDII= 0.02454
LIFT COEFFICIENT, CLII= 1.20000
PITCHING MOMENT COEFFICIENT, CMII= -0.07500
THE ROOT MEAN SQUARE OF CAMBER ORDINATES= 0.00050

THE 7TH ITERATION IN THE FINAL CYCLE, DELTA= 0.400
INDUCED DRAG COEFFICIENT, CDII= 0.02018
LIFT COEFFICIENT, CLII= 1.20000
PITCHING MOMENT COEFFICIENT, CMII= -0.07500
THE ROOT MEAN SQUARE OF CAMBER ORDINATES= 0.00046

THE 8TH ITERATION IN THE FINAL CYCLE, DELTA= 0.400
INDUCED DRAG COEFFICIENT, CDII= 0.01615
LIFT COEFFICIENT, CLII= 1.20000
PITCHING MOMENT COEFFICIENT, CMII= -0.07500
THE ROOT MEAN SQUARE OF CAMBER ORDINATES= 0.00044

THE 9TH ITERATION IN THE FINAL CYCLE, DELTA= 0.400
INDUCED DRAG COEFFICIENT, CDII= 0.01237
LIFT COEFFICIENT, CLII= 1.20000
PITCHING MOMENT COEFFICIENT, CMII= -0.07500
THE TWIST DISTRIBUTION IN THE SPANWISE DIRECTION

YLE(1)=	0.04743	ALPA0(1)=	8.58050
YLE(2)=	0.14229	ALPA0(2)=	18.26916
YLE(3)=	0.21014	ALPA0(3)=	-13.35170
YLE(4)=	0.25944	ALPA0(4)=	4.09779
YLE(5)=	0.30875	ALPA0(5)=	-10.28359
YLE(6)=	0.37411	ALPA0(6)=	11.19529
YLE(7)=	0.49688	ALPA0(7)=	3.86014
YLE(8)=	0.66458	ALPA0(8)=	3.46656
YLE(9)=	0.83229	ALPA0(9)=	1.20347
YLE(10)=	0.95506	ALPA0(10)=	-1.35737

CAMBER ORDINATES IN THE JET ON CASE

0.00770	0.05095	0.08393	0.06981	0.02866	0.00332
0.01452	0.09007	0.12577	0.08447	0.02843	0.00302
0.00134	0.02399	0.06068	0.07131	0.04191	0.00505
0.00597	0.05382	0.07719	0.04690	0.02129	0.00218
0.00105	0.02396	0.04997	0.05066	0.03258	0.00401
0.01422	0.08461	0.11489	0.08181	0.03076	0.00337
0.01141	0.07264	0.10950	0.08672	0.03636	0.00423
0.01090	0.07187	0.11509	0.09656	0.04255	0.00513
0.00882	0.06103	0.10401	0.09259	0.04315	0.00534
0.00572	0.04239	0.07835	0.07599	0.03840	0.00489
THE ROOT MEAN SQUARE OF CAMBER ORDINATES=				0.00041	

XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX

ALPHA = 0. DEGREES

XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX

VORTEX	XV	YV	CP	CPW
1	0.01704	0.04743	0.47346	0.27324
2	0.14645	0.04743	1.00333	0.69602
3	0.37059	0.04743	1.31955	0.95547
4	0.62941	0.04743	1.10117	0.76591
5	0.85355	0.04743	0.53810	0.31755
6	0.98296	0.04743	0.16716	0.08041
7	0.01704	0.14229	0.95024	0.44343
8	0.14645	0.14229	1.72062	0.91657
9	0.37059	0.14229	1.60856	0.93288
10	0.62941	0.14229	0.93595	0.61393
11	0.85355	0.14229	0.31193	0.21871
12	0.98296	0.14229	0.10460	0.06350
13	0.01704	0.21014	-1.85986	0.52313
14	0.14645	0.21014	2.19873	1.08728
15	0.37059	0.21014	4.36602	0.97367
16	0.62941	0.21014	3.36949	0.53386
17	0.85355	0.21014	2.39451	0.14443
18	0.98296	0.21014	1.00400	0.02075
19	0.01704	0.25944	-0.75528	0.53314
20	0.14645	0.25944	4.74276	1.12298
21	0.37059	0.25944	4.65973	0.98545
22	0.62941	0.25944	1.41030	0.52403
23	0.85355	0.25944	1.73256	0.13686
24	0.98296	0.25944	0.95776	0.00914
25	0.01704	0.30875	-1.59881	0.52548
26	0.14645	0.30875	2.74823	1.12427
27	0.37059	0.30875	3.97128	0.98979
28	0.62941	0.30875	2.64443	0.52630
29	0.85355	0.30875	2.67985	0.13835
30	0.98296	0.30875	1.15858	0.00357
31	0.01704	0.37411	0.70660	0.50901
32	0.14645	0.37411	1.61202	1.11257
33	0.37059	0.37411	1.47902	0.99236
34	0.62941	0.37411	1.02955	0.52534
35	0.85355	0.37411	0.48928	0.13237
36	0.98296	0.37411	0.14618	-0.00368
37	0.01704	0.49688	0.74190	0.46737
38	0.14645	0.49688	1.40284	1.06074
39	0.37059	0.49688	1.41070	0.98344
40	0.62941	0.49688	1.02394	0.52471
41	0.85355	0.49688	0.50286	0.12542
42	0.98296	0.49688	0.15149	-0.00870
43	0.01704	0.66458	0.67556	0.37828
44	0.14645	0.66458	1.29936	0.90573
45	0.37059	0.66458	1.40971	0.92505
46	0.62941	0.66458	1.09592	0.55977
47	0.85355	0.66458	0.57263	0.17927
48	0.98296	0.66458	0.18311	0.01716
49	0.01704	0.83229	0.52237	0.27428
50	0.14645	0.83229	1.04290	0.70117
51	0.37059	0.83229	1.22420	0.79535
52	0.62941	0.83229	1.01504	0.55616

53	0.85355	0.83229	0.57032	0.23663
54	0.98296	0.83229	0.18453	0.04868
55	0.01704	0.95506	0.32196	0.15589
56	0.14645	0.95506	0.62419	0.42816
57	0.37059	0.95506	0.74849	0.50533
58	0.62941	0.95506	0.64621	0.39131
59	0.85355	0.95506	0.39385	0.20976
60	0.98296	0.95506	0.12604	0.05351

Y/SP	CL	CM	CT	CDI	CLW	CMW	CDW
0.04743	0.94091	0.77565	0.	0.12627	0.64689	0.53890	0.05870
0.14229	1.09119	0.73811	0.	0.25540	0.63567	0.41331	0.03247
0.21014	2.74845	0.88267	0.	-0.67459	0.64609	0.33297	0.04727
0.25944	2.74741	0.90059	0.	0.11828	0.65168	0.25603	0.03664
0.30875	2.64799	0.22817	0.	-0.48506	0.65297	0.17240	0.02297
0.37411	1.08114	0.04516	0.	0.15507	0.64850	0.06084	0.01286
0.49688	1.02899	-0.29282	0.	0.01429	0.63204	-0.14489	0.00759
0.66458	1.03835	-0.75872	0.	0.01472	0.60313	-0.41597	-0.00433
0.83229	0.91279	-1.07154	0.	-0.01101	0.53726	-0.61765	-0.00805
0.95506	0.57151	-0.85388	0.	-0.02845	0.35902	-0.53237	-0.00783

JET - OFF SPAN LOADING

JET - ON SPAN LOADING

0.80084

1.16483

0.75122

1.28954

0.73756

3.13756

0.72490

3.05612

0.70726

2.86817

0.67731

1.12917

0.61414

0.99984

0.52611

0.90575

0.41526

0.70553

0.25138

0.40016

THE LIFT COEFFICIENT = 1.20000

TOTAL INDUCED DRAG COEFFICIENT = 0.01237

THE INDUCED DRAG PARAMETER = 0.00859

TOTAL PITCHING MOMENT COEFFICIENT = -0.07500

THE COANDA LIFT COEFFICIENT, CLR = 0.29103

THE COANDA DRAG COEFFICIENT, CDR = -1.21880

THE COANDA MOMENT COEFFICIENT, CMR = -0.09561

THE LIFT COEFFICIENT FOR THE WING ALONE = 0.57709

THE INDUCED DRAG COEFFICIENT FOR THE WING ALONE = 0.01552

THE PITCHING MOMENT COEFFICIENT FOR THE WING ALONE = -0.04943

THE INDUCED DRAG PARAMETER FOR THE WING ALONE = 0.04659